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Report
Soli
D. M. Jr.

SPOTTED OWL HABITAT USE

ON THE SIX RIVERS NATIONAL FOREST,

HUMBOLDT COUNTY, CALIFORNIA

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ABSTRACT

Twelve northern spotted owls, Strix occidentalis caurina, including 10 radio-tagged individuals, were observed on the Six Rivers National Forest, Humboldt County, California, between July 1980 and August 1981. Approximately 10,762 hours were accumulated while monitoring owl foraging, roosting, and nesting activities, determining food habits, and measuring habitat characteristics.

Owl pairs occupied a large home range area (mean=676.8 ha; 1692 ac) in which mature/old-growth tree stands comprised the greatest percentage of the total home range area. Home range size was correlated with habitat quality, both the availability and patchiness of habitat areas. Home range movements were influenced by physiographic features to a varied degree.

Multilayered, mature/old-growth tree stands within mixed evergreen forests were the only habitat type preferentially selected by the owls for foraging and roosting. Minimum stand size requirements for mature/old-growth tree stands approached 120 ha (300 ac). This requirement should not be confused with the owls minimum total area requirement for mature/old-growth tree stands; an area approaching 400 ha (1000 ac).

Thermoregulation apparently was a major factor influencing roosting habitat selection. Roosting habitat selection appeared constrained to a greater degree by habitat structure and physiographic characteristics, compared to foraging habitat selection.

Dusky-footed woodrats, Neotoma fuscipes, were the predominant prey species, comprising the greates percentage of all prey items (n=240) and of total biomass (n=24,368 g).

Spotted owls exhibited differential niche utilization, probably based on sexual dimorphism, and each sex exhibited specific habitat selection for foraging and roosting. Differential niche utilization by the sexes probably reduced intersexual competition for food. Stand structure (decadence, tree density and basal area, and shrub cover) and physiography (elevation) was shown to effectively discriminate habitat use between the sexes.

Similarly, specific habitat selection for each sex was effectively distinguished by differences in stand structure (canopy closure, tree density and basal area) and physiography (aspect and elevation) of roosting and foraging habitat areas. The distinctions in habitat selection, however, were attributed to subtle differences in habitat structure or physiographic characteristics, suggesting that spotted owls were specific in their habitat requirements. Thus, habitat suitability was partially determined by an interaction of sexual, habitat structure, and physiographic characteristics.

ACKNOWLEDGEMENTS

Funding for this research was generously provided by the Six Rivers National Forest, Eureka, California, and administered by the Humboldt State University Foundation, Arcata, California. Jack Kahl, Ron Escano, and Ed Toth provided the opportunity. Jack Kahl and Ed Toth were constant sources of support; their patience was unending. Logistical support was provided by the Lower Trinity and Orleans Ranger Districts and by the Supervisors Office, Eureka, California.

The study benefited by discussions with Eric Forsman, James Harper, Bruce G. Marcot, Martin G. Raphael, Ed Toth, Barry Noon, and especially Rocky Gutierrez.

I am extremely appreciative for the determination and dedication exhibited by Pat "Ranger" Ward, Pat Manley, Phil McKay, and Chuck Sisco, during final phases of this study. Their efforts ultimately resulted in the successful completion and outcome of this study. Phil McKay, Chuck Sisco, and Pat Manley dissected owl castings and identified prey remains. Chuck Sisco, specifically, deserves special recognition for his overwhelming contribution of time, interest, and dedication to the the project and for shouldering most of the burden in the field.

Numerous people also contributed their time during various phases of the study, including Paula Crumpton, Sally

Walters, Rich Callas, Jack Miller, Greg Leisten, Pat-Hall Leisten, Tim Dougherty, and others. Patrick Collins provided invaluable assistance with the development of computer programs.

Ed Toth and Rocky Gutierrez critically reviewed and made constructive comments on the manuscript.

Mosquito Break gave me a break and let me finish the study. I'll forever be grateful to Pat "Ranger" Ward for saving my life in Mosquito Creek.

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INTRODUCTION

The northern spotted owl, Strix occidentalis caurina, is thought to have declined in numbers throughout its range (U.S. Fish and Wildlife Service 1982). Consequently, many recent studies have occurred to elucidate its little known habits. Forsman (1976) reported on the distribution and general biology of the spotted owl. Forsman (1980, 1981) investigated general habitat selection by spotted owls on the west slope of the Cascades and the Coast Range of Oregon, during radio-telemetry studies. He indicated that old-growth conifer forests were preferred foraging and roosting habitats. Data specific to roosting habitat appears to be related to thermoregulatory and bioenergetic considerations (Forsman 1976; Barrows and Barrows 1978; Barrows 1981).

However, relatively little is known of the specific habitat requirements of this owl, a prerequisite for the proper management and protection of this Sensitive species (U.S. Forest Service 1978). This project was initiated to gather this habitat information. The objectives of the study were to: estimate home range size; determine preferred foraging and roosting habitats; and describe owl habitat structure.

STUDY AREA

Three study areas were selected within the Six Rivers National Forest, Humboldt County, California. These areas were: Leary Creek, 10 km (6 mi) southwest of Orleans California (Figs. 1 and 2); and Fourmile Creek and Mosquito Creek, 6 and 19 km (4 and 12 mi) south of Willow Creek, California, respectively (Figs. 1 and 3).

Topography and Climate

The Leary Creek and Mosquito Creek study areas were characterized by steep ridges (40-110 percent slope gradient) within deep drainages. The Fourmile Creek area, in contrast, was located on the moderately sloped (15-70 percent) southeast face of Brush Mountain. Elevations on the Leary Creek, Mosquito Creek, and Fourmile Creek study areas ranged from 242 to 1200 m (800 to 4026 ft), 848 to 1342 m (2800 to 4430 ft), and 487 to 1207 m (1600 to 3486 ft), respectively.

Hot, dry summers and cold, wet winters typified the climate of each area. Six Rivers National Forest precipitation records at Willow Creek and Orleans, California, indicated that annual precipitation averaged 1238 cm (61.2 in). Peak rainfall periods occurred between October and

April. Precipitation on the study areas were probably higher because of elevation.

Vegetation

Each area was representative of a mixed evergreen forest with chinquapin, Castanopsis chrysophylla, or rhododendron, Rhododendron macrophyllum, (Kuchler 1977). The vegetation of these forests have also been described by Sawyer et al. (1977) as the mixed evergreen forest and by Ericksen (1980) as the Douglas-fir/tanoak/madrone (Pseudotsuga menziesii/Lithocarpus densiflorus/Arbutus menziesii) CALVEG series.

The following description of the vegetation in these forests follow Sawyer et al. (1977). Although vegetation in the Leary Creek area represented forests of the Klamath Mountains and that of the Fourmile Creek and Mosquito Creek areas represented forests of the North Coast Range, forests of each area were similar in structure and composition. The forests of each area also represented the Pseudotsuga-hardwood type of the mixed evergreen forest.

Dominant tree within the Pseudotsuga-hardwood type on each study area were Douglas-fir, tanoak, and Pacific madrone. These were found in association with canyon-live oak, Quercus chrysolepis, Oregon white oak, Quercus garryana, California black oak, Quercus kelloggii, big-leaf maple, Acer macrophyllum, incense cedar, Libocedrus

decurrens, Pacific yew, Taxus brevifolia, and chinquapin. California black oak and Oregon white oak occasionally occurred as pure stands on drier upland sites. Big-leaf maple and Pacific yew were more abundant on mesic sites.

Sites below 1212 m (4000 ft) were typically multilayered, with Douglas-fir forming an open to dense canopy as tall as 79 m (260 ft). A more continuous lower canopy was formed by tanoak, which reached 38 m (126 ft) in height. Secondary components on more mesic slopes were typically dense and composed of tanoak, salal, Gaultheria shallon, mountain dogwood, Cornus nuttallii, California huckleberry, Vaccinium ovatum, and barberry, Berberis nervosa. Poison oak, Rhus diversiloba, and wood rose, Rosa gymnocarpa, were found on more xeric slopes. The herb layer was sparse and included redwood sorrel, Oxalis oregona, Yerba de selva, Whipplea modesta, and Vancouveria hexandra. Species of fern included sword fern, Polystichum munitum, and bracken fern, Pteridium aquilinum.

Low elevation Pseudotsuga-hardwood type forests, however, gave way to Coast Range Montane forests above 1271 m (4200 ft) on the northwest periphery of the Mosquito Creek study area (Fig. 4). These forests were dominated by white fir, Abies concolor; it was found in association with ponderosa pine, Pinus ponderosa, sugar pine, Pinus lambertiana, and incense cedar (Küchler 1977). In deference to his study, we did not find ponderosa pine as an associated species.

Structurally, Coast Range Montane forest stands were characterized by tall (67 m; 210 ft), moderately open to dense, single-layered canopies, which were subtended by poorly developed understories. A diversified mixture of broad-leaved evergreen shrubs, including snowbush, Ceanothus cordulatus, and pine mat manzanita, Arctostaphylos nevadensis, occurred in occasional patches (Küchler 1977).

Land Use and Diversity

Fire, geologic and topographic diversity, and past land use practices have produced a complex mixture of different aged stands within forests of the region (Sawyer et al. 1977). Timber management, particularly, has been the dominant land use. Approximately 17, 18, and 30 percent of the Leary Creek, Fourmile Creek, and Mosquito Creek areas, respectively, were in early successional stages as a result of logging. Intensively logged areas occurred northeast of the Fourmile Creek area and east of the Mosquito Creek study areas. These had been cut during the early 1950's. Cover of recent clearcut areas ranged from bare ground to dense mixtures of shrubs, grasses, forbs or seedling. Older clearcuts generally contained denser shrub/seedling/sapling tree mixtures, which were occasionally interspersed with grass/forb openings. Clearcut openings ranged from 3 ha (7 ac) to greater than 40 ha (100 ac) in size.

Silviculturally treated areas, salvage sale and thinning areas, occurred on two study sites. Salvage cutting is the removal of deteriorating, dying, or dead trees, and a thinning is the selective removal of trees to improve the form of remaining trees (Thomas 1979).

The Bowl Salvage Sale and Brush Flood Salvage Sale areas occurred within the Fourmile Creek study area (Fig. 5). The Bowl Salvage Sale was an individual tree mark area, 2 ha (5 ac) in size, with a residual basal area of 34 m^2/ha (150 ft^2/ac). I could not determine the year in which harvesting took place. The Brush Flood Salvage Sale was a selective tree mark area, 98 ha (246 ac) in size, harvested during 1965 (residual basal area unknown). Snags were fallen, and slash had been lopped (cut into smaller pieces) and scattered throughout the area.

Two individual tree mark units (Sims Ranch Units 11 and 14) occurred within the Mosquito Creek study area, both units were 2 ha (6 ac) in size (Fig. 6). The prescription for Unit 11 indicated that all trees greater than 85 cm (34 in) were cut, leaving trees in the understory ranging frm 20 to 85 cm (8 to 34 in) in diameter at breast height (DBH). The recommended residual basal area was 29 m^2/ha (230 ft^2/ac). An understory burn was accomplished in this stand during spring 1981. Specific recommendations for Unit 14 were not available.

Contiguous stands of mature/old-growth timber ranged from 2.0 to 400+ ha (5 to 1000+ ac) in size. Paved or secondary gravel roads were located throughout each study area.

METHODS

Terms used throughout this paper are defined in Appendix A.

Sex and Age Identification

Forsman (1976) describes the identification of the sexes and of immature owls.

Species Capture

Vocal imitation of spotted owl calls were used to locate or attract owls during the day. Prey-baited mist nets (mesh size=10 cm; 4 in) were then placed 3 to 5 m (6 to 17 ft) downslope from their roost locatons. No birds were injured during their capture. In addition, no adverse effects on the birds could be attributed to their capture or to radio packages. Some owls were banded with U.S. Fish and Wildlife Service metal leg bands and colored plastic leg bands to aid in their identification after their release (Appendix B).

Radio-telemetry

Equipment

Telonics, Inc., Mesa, Arizona, supplied the following radio-telemetry equipment: hand-held portable receivers (Models TR2 and TR-2E); two element, hand-held Yagi and single element, omnidirectional, roof mounted mobile antennas, Models RA-2A and RA-5A, respectively; low impedence (4-16 ohm) headphones; and back-pack style, hermetically sealed transmitters weighing 22 to 27 g (.8 to 1.0 oz). Transmitters were attached to owls using tubular, woven teflon strapping. AVM Instrument Co., Champaign, Illinois, supplied back-pack style, acrylic sealed transmitters weighing 21 to 23 g (.7 to .8 oz), which were attached to owls using silicone coated, fiberglass cord.

Method and Bias

Owl locations were determined by radio-triangulation using the loudest signal method (Springer 1979). Although this method has been shown to have a sampling error (standard deviation) of 3.9 degrees, the bias (0.2 degrees) is relatively small, compared to other methods (Springer 1979).

Extreme efforts were made to reduce the size of error polygons associated with plotted telemetry locations (a "fix"). Error polygons represented the area formed by three

or more converging bearings around a fix. Approximately 97 percent of all fixes (n=1371) had error polygons less than 1 ha (2.5 ac) in size. The low number of established fixes reflect the time required to determine accurate locations.

Working distances between an observer and foraging or roosting owls seldom exceeded 400 m (1320 ft) and, at times, were within 36 m (120 ft) or less of foraging owls. At night, noise and glowing lights were minimized to reduce influences on owl foraging behavior. Observer fatigue, topography, precipition, the distance between an observer and radio-tagged owls, time intervals between established radio bearings, and an owl's movements influenced fix accuracy.

Techniques

Owls were radio-tracked from vehicles and aircraft, or on foot. Owl locations were determined only using hand-held antennas and a compass. Roof-mounted, onmidirectional antennas were only used to detect an owl's presence or movements.

Owl foraging activities were monitored at night by selecting an individual owl, establishing its location, and following it for up to one-half of the night, then moving on to another bird (after Forsman 1980). However, several closely spaced owls, at times, were monitored simultaneously to maximize data collection and to enhance behavioral observations (after Forsman 1980). Fixes were only obtained when

owls changed their location, as determined by changes in signal intensity and direction. Effort were made to vary monitoring sequences and to collect equal sample sizes for each owl. However, equipment failure, primarily, and weather precluded the collection of equal sample sizes for each owl and of data throughout the year.

During the day, roosting owls were physically located on their roosts or triangulated; some were checked several times a day (after Forsman 1980). A total of 37 variables were measured at each roost site. Acronyms, descriptions, and sampling methods for roost site variables are presented in Appendix C.

Aircraft were used on several occasions to locate owls when ground searches failed to reveal their presence. High wing and low wing aircraft were used in aerial telemetry. The long axes of Yagi antenna elements were positioned parallel to the plane's fuelage, the antenna handle firmly secured parallel to each wing strut or step using electrical tape and hose clamps. An omnidirectinal antenna was secured to the bottom of the plane's fuselage. Grid patterns were flown over an area until a signal was received by the omnidirectional antenna. Afterwards, directional Yagi antennas were used to pinpoint the signal by simultaneously flying toward the signal's direction, circling in the area of peak signal strength, and lowering the aircraft in elevation. Ground searches then refined the locations.

Data Collection

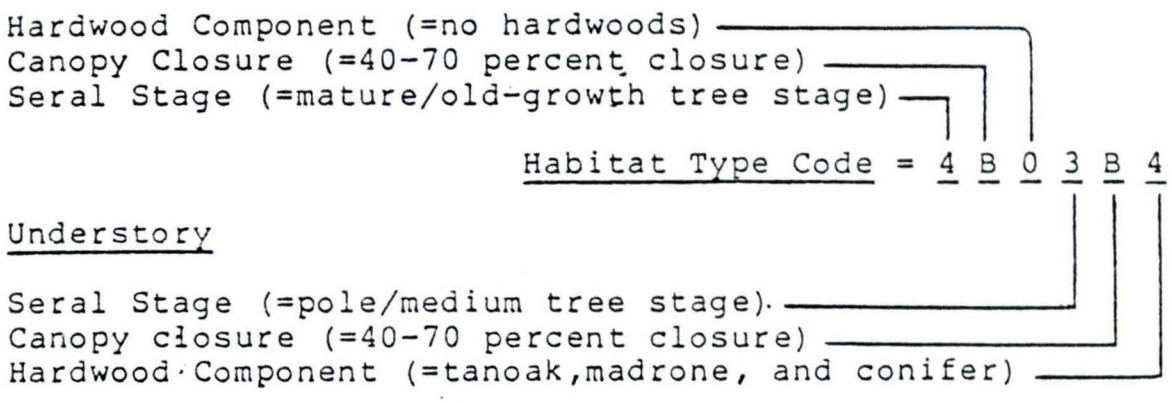
The following data were recorded for each plotted fix: owl identity; date; Standard Time; owl activity code; fix accuracy; and habitat type (after Forsman 1980). Seven owl activities were recognized: foraging; roosting; moving; calling; territorial interaction; on nest; and unknown (after Forsman 1980).

Five fix accuracy levels were recognized: visual location; accurate to within 1.0 ha (2.5 ac); accurate to within 2.0 ha (5.0 ac); accurate to within 8.0 ha (20.0 ac); and accurate to within 20.0 ha (50.0 ac) (after Forsman 1980). Unless locations with an accuracy of 20.0 ha fell within a polygon and were greater than 505 m (1665 ft) from its boundary, locations with an accuracy of 8 ha were considered the limit for habitat selection analyses (after Forsman 1980).

Habitat type mapping

WRIS timber stand information from 1974 timber stand maps (scale=1:24,000) were converted to a six digit habitat type code for each timber stand polygon. Habitat type codes were developed by Ed Toth, Land Planning Biologist, Six Rivers National Forest, based on criteria established in the North Coast/Cascade Zone portion of the California/Wildlife Habitat Relationships program (WHR) (Marcot 1979) (Table 1).

Habitat type codes give seral stage, canopy closure, and hardwood component information for overstory and understory tree layers, respectively. Definitions for habitat type codes may be derived by following alpha/numerical codes in Table 1. For example:


Overstory
Hardwood Component (=no hardwoods)
Canopy Closure (=40-70 percent closure)
Seral Stage (=mature/old-growth tree stage)
Habitat Type Code = 4 B 0 3 B 4
Understory
Seral Stage (=pole/medium tree stage)
Canopy closure (=40-70 percent closure)
Hardwood Component (=tanoak,madrone, and conifer)

A total of 108 distinct habitat type codes were recognized forest-wide, 42 occurred within the study areas. Field checks indicated a need to verify habitat type code accuracy. An effort was made to verify the coding accuracy for all polygons in which owl locations were plotted. Time and fiscal constraints precluded mapping and delineating habitats which occurred on private lands.

Mapping error of the original WRIS timber stand information used to construct habitat type codes was approximately ±10 percent (±60.6 m; ±200 ft horizontal mapping control). Errors associated with the correct identification of polygon characteristics (i.e., size class, canopy closure, and species composition) were not determined. Habitat type

acreages were determined from computer printouts supplied by the Six Rivers National Forest, Eureka, Caliifornia, or with a polar planimeter. Three planimeter readings were taken, then averaged.

Habitat Selection Analysis

Neu et al. (1974) and Forsman (1980) describe Chi-square and habitat selection analyses used to determine if certain habitat types were selected over others for foraging or roosting. My hypothesis was that spotted owls preferentially avoided or selected certain habitat types for foraging or roosting.

Home Range Analysis

Jennerich and Turner (1969) describe the minimum convex polygon method used to determine home range size. Home range areas were measured using a polar planimeter; three readings were averaged.

Home range estimates probably represented a minimum because of the relatively small total observation periods for most owls. Forsman (1980) required a relatively long period of time (mean=165 days; range=105-204 days) to determine 90 percent of an owl's total home range area. Since most owl's total observation periods fell below this mean, all fixes were used to determine each owl's home range size.

Further, all fixes were used to determine the home range size for owls with observation periods exceeding 240 days, because they remained within their usual activity areas.

Vegetation Analysis

A total of 230 variables (179 tree; 40 shrub; 6 ground cover; 5 physiographic) were measured or investigated at plotted foraging locations within core and non-core areas and at verified roost locations. Acronyms, descriptions, and methods for variables describing foraging and roosting vegetation plots are given in Appendix C. Scientific names of plant species follow Munz (1959).

Sampling Bias, Period, and Intensity

All vegetation plots were stratified by individual and randomly selected from data collected during the breeding season. These plots were measured during August and September 1981. Six non-core area foraging locations (n=48) were sampled per owl. Core area foraging locations (n=382) and verified roost loations (n=50) were sampled in proportion to the total observed for each owl. Non-core and roost location sampling intensities were allocated by time and fiscal constraints.

Food Habits

Food habits analyses and methods followed Maser and Brodie (1966) and Forsman (1976,1980). Mammal skeletal materials were identified by comparison to known specimens in the Vertebrate Museum, Humboldt State University, Arcata, California, and by personnel at the Museum of Vertebrate Zoology, University of California, Berkeley, California. Dr. Richard Hurley, entomologist in the Department of Zoology, Humboldt State University, identified insect exoskeletons.

Data Processing

Data were entered on computer cards and processed on computer facilities at Humboldt State University , Arcata, California, using the Statistical Package for the Social Sciences (SPSS) - version 8 (Nie et al. 1975).

Data Analysis

Techniques of Data Analysis

Multivariate statistical procedures (principal component, factor, and discriminant analyses) described by Nie et al. (1975) were used to analyze entire data sets. The specific technique used was a function of the analysis ob-

jective. Principal component and factor analyses were used because of their data reduction capabilities. Principal component analysis, specifically, was used to reduce the redunancy of information between variables from vegetation plots measured during the pilot study. Redundant variables supply no additional information. Factor analysis was used to construct hypothesis concerning roosting habitat selection.

A closely related technique, discriminant analysis (stepwise), was used to examine the relationships between habitat areas (roost, core and non-core areas) or between the sexes. Each habitat area or sex was ordinated along one or several environmental gradients. The results were used to test the hypothesis and to make inferences that: differential use of habitat areas by spotted owls was correlated with the structural, vegetative, or physiographic characteristics of habitat areas; and that differences between the sexes were related to differential niche utilization, probably based on sexual dimorphism.

Highly correlated variables ($r \geq .65$) were removed prior to entry in the discriminant analysis. Variables with the greatest among group variation or ecological interpretation were retained if high correlations resulted after initial analyses. Group sizes were approximately equal for each analysis. Discriminant function(s) were interpreted by using the correlations between values of the original variables and the discriminant function(s).

Classification procedures which correctly classified a large portion of the original data set to their original group, based on discriminant score alone, were considered successful.

The assumptions and limitations behind inferences, based on habitat sampling and discriminant analyses, included the following (1-7 follow Mosconi and Hutto 1981):

1. Factors other than vegetation structure (see Discussion on Habitat Selection) may influence spotted owl habitat selection.

2. Plotted telemetry locations were assumed to represent an owl's actual location.

3. Spotted owl habitat requirements were assumed to be adequately represented by the habitat variables which were measured or investigated.

4. Roosting and core area habitats were assumed to represent optimal habitats. The importance of optimal habitats should be viewed with respect to a population's nesting success. Nesting success was observed to vary.

5. The sample of spotted owls which were monitored were assumed to be representative members of a spotted owl population.

6. Spotted owls were assumed to be inflexible in their foraging and roosting behavior. However, their behavior and, hence, habitat requirements may vary seasonally or between habitat areas.

7. The statistical theory of discriminant analysis assumes equal variance-covariance matrices within each group. Box's M-test (Klecka 1975) indicated that variance-covariance matrices were significantly different ($P<.001$). This assumption need not be strongly adhered to as the technique is considered robust enough to acommodate failures to meet this assumption (Klecka 1975; Raphael 1981).

8. One disadvantage to most multivariate techniques is that their matrices are based on Pearson product-moment correlation coefficients. Although these are technically invalid for ordinal types of data, they may be considered as useful exploratory or model building tools when analyzing this type of data (Klecka 1975).

9. The multivariate normal distribution is the mathematical model on which multivariate statistical procedures are based. All variables used in multivariate analyses approached normality.

Chi-square analysis was used to test the equality of non-parametric means, and univariate analysis of variance (ANOVA) techniques and t-tests were similarly applied to parametric data. The Least Significance Distance (LSD) procedure were used to determine where differences existed between means. Arcsine transformations (Zar 1974) were used where applicable.

Statistical Significance

A confidence level of 95 percent was chosen for all statistical tests. A probability of .01 percent was considered highly significant.

Pilot Study

A pilot study was conducted between 15 June and 30 September of the 1980 field season. Its objectives were to: select primary and alternate study areas; establish an initial sampling frame; evaluate data collection, species capture, and radio-telemetry techniques; allow field personnel

to gain the expertise required to obtain accurate and precise telemetry data; and refine the initial sampling frame through data collection and exploratory data analysis. Data were gathered on the foraging and roosting activites of three radio-tagged adult owls (two males and one female) and one immature female owl (Table 2).

With several exceptions, methods used during the pilot study were identical to those described for the final phase of the study (see earlier sections). During the pilot study, canopy closure (CCLOS) was estimated from plot center, using a spherical densiometer. Four densiometer readings were taken, then averaged. During the final phase of the study, several ground cover variables (e.g., litter, bare soil, rock, and moss) were consolidated into one variable (LITTER). Principle component analysis indicated that these variables were redundant. Bare soil, rock, and moss, in combination, contributed less than five percent of the line intercept path, on the average. Radio-transmitters supplied by Telonics, Inc., Mesa, Arizona, were the only transmitters used during the final phase of the study.

A total of 59 vegetation plots, representing foraging locations within core areas, were measured during fall 1980. Plots were stratified by individual and randomly selected from data collected during the breeding season. Sampling intensity was proportional to the number of observations for each owl. These plots were then used to determine the sample size which was used to describe core areas during

the final phase of the study (Snedecor 1950 in Schemnitz 1980). Sample size was established to estimate every vegetation variable within 5 percent of the mean, 95 percent of the time.

RESULTS AND DISCUSSION

Macrohabitat Analysis

Between 9 July 1980 and 24 August 1981, approximateimately 10,762 hours (day=5148; night=5614, distributed over 21 people, were spent in the field study of 12 northern spotted owls on the Six Rivers National Forest, Humboldt County, California. Ten owls (five adult males, two adult females, one immature male, and two immature females) were radio-tagged and tracked a total of 10 to 241 days (Table 2). Five of these owls, consisting of three adult males and two females, represented members of three pairs, which were radio-tagged and tracked a total of 96 to 241 days. A total of 1371 locations were suitable for home range analyses (Table 3). Injuries or changes in the natural activities of radio-tagged owls were not noticed or could be attributed to the attached radio-transmitters. One owl, a mature male (Bubba), died during the study. His death coincided with his movement away from his usual activity area, and it was attributed to natural causes.

Distribution and Spacing of Individuals

During the pilot study, an adult male (Uno) and an immature female (Nieve) were captured and radio-tagged in the Leary Creek drainage (Table 2). Defective radio trans-

mitters resulted in relatively short observation periods for both owls. However, sufficient data were gathered between July and August 1980 to estimate Uno's home range area (Fig. 7; Table 4). Intensive ground searches between June and September 1980 failed to reveal any other owl's presence in the Leary Creek area. This apparent lack of response could have been attributed to high temperatures (day=35 °C; 95 °F; night=29 °C; 85 °F) during this period. Six Rivers National Forest surveys revealed the presence of spotted owls within 5 km (3 mi) of the Leary Creek drainage during 1980 (Fig. 2).

During a 10 day observation period in September 1980, the immature female (Nieve) was located roosting with an adult male (Despacio) in an area approximately 1.2 km (.8 mi) east of Uno's initial capture location. These owls roosted together in this general vicinity for three days. One week later, I located the immature female (Nieve), foraging in a mature/old-growth tree stand, approximately 5 km (3 mi) south of her initial capture location, where she remained throughout the night and following day (Fig. 2). Extensive ground searches in this area failed to reveal her or any other spotted owl's presence after this time. This lack of calling response could have been attributed to a waning of territorial aggression in owls of the area or to Nieve's dispersal from the area. Subsequent failures with other radio transmitters led me to conclude that Nieve's radio transmitter had also failed.

The Fourmile Creek pair were observed throughout the study (Figs. 8-10; Table 2). Ground searches during 1980 and 1981 verified the presence of three adjacent spotted owl pairs within 5 km (3 mi) from the center of this pair's activity area (Fig. 3). Topography and access precluded studying these other pairs.

This study focused on the Mosquito Creek drainage and adjacent areas, where six owls (three adult males, one adult female, one immature male, and one immature female) were radio-tagged (Figs. 4 and 11-16; Table 2). Owls of the Mosquito Creek area included two nesting pair; one pair located near Bee Tree Creek, the other near Sugarloaf Mountain. Observations were also made on the untagged nesting female at Sugarloaf Mountain. Because of their initial affinity for the Sugarloaf Mountain area, it appeared that the immature owls, Chopo (a male) and Suave (a female), were young produced by the Sugarloaf Mountain pair during 1979 or 1980.

Although ground searches during the spring and summer of 1981 failed to reveal the presence of spotted owls in the vicinity of Mosquito Creek, untagged male and female spotted owls were heard throughout the Mosquito Creek study area on seven occasions. I could not determine their usual activity areas because of a lack of calling response. However, Six Rivers National Forest surveys have revealed the presence of several spotted owls within 10 km (6 mi) of the Mosquito Creek drainage, since 1979 (Fig. 3).

Spotted owl pairs I observed on the Six Rivers National Forest during 1980-1981 were spaced at intervals ranging from 2.4 to 10 km (1.4-6 mi). These intervals are similar to those Gould (1974) reported for California (statewide), but they are some what higher than Marcot (1978) reported for the Six Rivers National Forest.

Home Range Characteristics

Well defined home range areas, with one exception, were characteristic. An immature male (Chopo) lacked a well defined home range area; he wandered extensively over a total area of 2319 ha (5799 ac) (Fig. 16). Therefore, this owl was excluded from home range analyses because the dispersal nature of its movements would have exaggerated home range estimates.

Chopo initially occupied an area 126 ha (316 ac) in size near Sugarloaf Mountain, during May 1981. He wandered approximately 4 km (2.5 mi) south of Sugarloaf Mountain and returned near his initial activity area on several occasions, during June 1981. Forested habitats along Mosquito Creek were used during his movements to and from Sugarloaf Mountain. Between mid-June and August 1981, all of his movements occurred within a 606 ha (1515 ac) area near Grouse Creek, a maximum of 10 km (6 mi) from his initial activity area (Fig. 16). The lack of an adequate road network greatly reduced the opportunity for observation in the

Grouse Creek area. Brown (1975) indicated that unstable home ranges are characteristic of dispersing animals.

Portions of the Grouse Creek area were privately owned. Consequently, habitat type information was not available. Time and fiscal constraints precluded field checking and delineating habitat types on these private lands. My subjective impression, however, was that the dominant vegetation on these private lands was a mosaic of open, grassy areas and pole/medium sized hardwood stands. Canyon-live oak was the dominant tree species; it was found in association with Oregon white oak, California black oak, tanoak, and Douglas-fir. Douglas-fir also occurred in small patches (<10 ha; 25 ac) which contained the above hardwoods and were scattered throughout the area. I considered the Grouse Creek area as very marginal habitat. Although hardwood stands were used for foraging and roosting to some extent, Chopo appeared to "hop" from one patch of suitable conifer habitat to another while foraging.

Home range size. Home range sizes, based on the minimum convex polygon method, for the eight intensively studied owls are presented in Table 4. They represented minimum home range estimates because of the relatively short duration of study.

Owl pairs did not occupy a significantly greater mean collective home range area (676.8 ha; 1692 ac), compared to individual home range areas (412.8 ha; 1032 ac) ($P>.50$; $t=.585$; $df=6$). Adult females did not occupy a sig-

nificantly greater mean home range area (527.2 ha; 1318 ac), compared to adult males (337.6 ha; 844 ac) ($P>.50$; $t=.443$; $df=6$). Mean home range size estimates (total, males, and females) shown in Table 4, under groups defined by (1) all ages combined and (2) adults only, did not differ significantly ($P>.05$; $F=.067$; $df=5,42$).

Influence of habitat quality on home range size. The relationships between home range size and the availability (total area) and patchiness (number of patches) of habitat types (seral stages) within home range boundaries (i.e., habitat quality) are shown in Figs. 17 and 18, respectively.

Home range size was correlated with both the availability and patchiness of each habitat type. Significant correlations, however, occurred between home range size and the availability of seral stage 4 ($r=.90$; $P<.005$; $t=5.057$; $df=6$) and of seral stage 2 ($r=.72$; $P<.05$; $t=2.546$; $df=6$). All other correlations were not significant. These data suggest that the owls needed greater total areas or larger, more contiguous patches of their preferred habitats as the availability of "less desirable" habitats (seral stages 2 or 3) or the patchiness of preferred habitats (seral stage 4) increased (see Habitat Selection).

Discussion: My estimates of mean home range size for individual owls and owl pairs were smaller than Forsman (1980, 1981) reported for spotted owls in Oregon. This would be expected, based on my relatively shorter observation periods. However, my data compliment three month ob-

servation periods by Forsman (1980) for spotted owls in the west-central Oregon Cascades.

Nicholls and Warner (1972) estimated an average home range size of 226 ha (565 ac) (range=85-364 ha; 213-912 ac) for barred owls, Strix varia, in Minnesota. Southern (1970) reported a mean "territory" size of 18.2 ha (45 ac) for tawny owls, Strix aluco, in Great Britain. In contrast, "territory" sizes for tawny owls ranged from 27-182 ha (67-450 ac) in Denmark and Germany (Uttendorfer 1939, Anderson 1961, and Wendland 1963 as discussed by Southern 1970). Southern suggested these variations might be attributed to differences in the habitats of each area.

Schoener (1968) concluded that interspecific variation in home range size of birds was strongly correlated with body size and the relative density and accessibility of food resouces. The home ranges of raptors (Craighead and Craighead 1969) and small mammals (McNab 1963) have been shown to increase as prey availability decreases.

Schoener (1968) also hypothesized that variations in home range or territory size within a species were influenced by the number of individuals in a territory and the number of individuals of the same species or of other species in the area. Researchers have shown that intraspecific variation in home range or territory size may be influenced by an individual's characteristics (sex: Fitch and Shirer 1970; Brown 1975; Forsman 1980, 1981; aggression: Condor 1948; age: Schaeffer 1953; Stefanski 1967; Ralph and

Peterson 1971). Some species have been shown to increase their territory or home range size as preferred habitats become sparsely distributed (Miller 1931; Ericksen 1938; Odum 1941; Howell 1952; Southern 1970; Forsman 1980, 1981).

Composition of habitat types within home range area. Home range composition information is summarized by seral stage and presented in Table 4. On the average, seral stage 4 (mature/old-growth tree stands) accounted for the greatest total acreage within home range areas, followed by seral stage 3 (pole/medium tree stands) and seral stage 2 (brush/seedling/sapling tree stands).

The mean total acreage of mature/old-growth timber within a pair's collective home range area was not significantly greater, compared to an individual's home range area ($P>.50$; $t=.279$; $df=8$). However, a greater area of mature/old-growth timber may be required for a nesting pair's stability.

The percentage of the total home range area occupied by mature/old-growth timber appeared constant and approached an average of 44 percent. Therefore, the mean composition of habitat types within individual home range areas was compared to the available composition of habitat types. The average percentage (43.4 percent) of individual home range areas occupied by mature/old-growth timber was not significantly greater than could be expected by chance (35.2 percent) ($P>.50$; $t=.197$; $df=14$). The average percentage (25.4 percent) of individual home range areas occupied by pole/

medium tree stands was not significantly less than could be expected by chance (33.5 percent) ($P>.50$; $t=.306$; $df=14$). Similarly, the average percentage (30.1 percent) of individual home range areas occupied by brush/seedling/sapling tree stands was not significantly less than expected by chance (32.6 percent) ($P>.50$; $t=.152$; $df=14$). These results, however, suggest a tendency for spotted owls to encorporate a greater percentage of mature/old-growth timber within their home range areas, which was accompanied by a decrease in the percentage of "less desirable" habitats.

Home range overlap. An adult male (Bubba) was excluded from portion of home range overlap analyses, because some overlaps with his home range did not occur until after his death. For example, Fig. 15 indicates that the Bee Tree Creek female (Catalina) overlapped approximately 88 percent of this males's home range. Prior to Bubba's death, however, Catalina's foraging and roosting activities were confined to the slopes between Ammon Ridge and Mosquito Creek, north of Bubba's home range area. Consequently, their home range areas did not overlap. Within five days of Bubba's death, however, Catalina was located within Bubba's last activity area. This area was approximately 2 km (1 mi) south of her usual activity area.

Neighboring owls were typically exluded from an owl pair's overlap area. For example, the immature female (Suave) overlapped approximately 99 percent of the nesting male's (Harvey) home range area near Sugarloaf Mountain

(Figs. 11 and 13). The female was not observed to forage within 300 m (1000 ft) of the Sugarloaf Mountain nest tree; the nesting pair's major foraging and roosting area (Fig. 13). Interactions between the immature female and the nesting male were verified on two occasions in an area approximately 300 m west of the male's nest. Similarly, the solitary male (Bubba) did not approach within approximately 1212 m (4000 ft) of the Bee Tree Creek nest (Fig.12). The immature female (Suave) only overlapped seven percent of the nesting pair's collective home range area near Bee Tree Creek.

Paired owls overlapped home range areas to a greater degree (mean=62 percent; range=40.9-69.6 percent; n=4 overlaps), compared to any owls with overlapping home range areas (mean=39 percent; range=2.0-98.9 percent; n=12 overlaps). Spotted owl home range overlaps also included the following: male/female (mean=52 percent; range=2.0-98.9 percent; n=8 overlaps), female/female (mean=10 percent; range= 9.4-11.3 percent; n=2 overlaps), and male/male (mean=3 percent; range=2.0-2.5 percent; n=2 overlaps). These results suggest intolerance by the sexes.

All owls, regardless of age or breeding status (paired or unpaired), responded to vocal imitations of spotted owl calls with calling behavior.

Spotted owl home range areas also overlapped great horned owl, Bubo virginianus, use areas. Spotted owls responded to calling great horned owls by leaving the area

(three observations) or by approaching within 76 m (250 ft) of calling great horned owls (two observations). When approaching great horned owls, spotted owls called continuously and in an agitated manner, then remained in the area. It was not known if great horned owls reamined in the area on either occasion.

Discussion: My estimates for mean male/female overlap and the overlap between any two owls with adjacent home ranges areas were greater than those reported by Forsman (1980). This could be attributed to a patchy distribution of preferred habitats or to the relative spotted owl densities in my areas. Craighead and Craighead (1969) indicated that home range overlap of some raptor species in Michigan might result from the distribution of nesting and foraging areas or of vegetation.

Forsman (1980) suggested that the principle function of territorial behavior in spotted owls was to exclude potential competitors for mates. The relative intolerance by the sexes tend to substantiate this. However, it appeared that territorial aggression was exhibited both by paired and by unpaired owls (the adult male, Bubba). Territorial behavior by a non-paired owl might have been attributed to an inadequate food resource within its home range area. Hinde (1956), Schoener (1968), and Brown (1975) have discussed the hypothesized functions of territoriality, including: the guarantee of a food supply; pair bond maintenance; defense of nest and young; and others.

Influence of physiography on movements within home range areas. The influence of physiographic features upon owl movements within home range areas varied. Foraging and roosting owls used streams when moving from one area to another. One adult male appeared to concentrate his activities and movements along Mosquito Creek and its tributaries (Fig. 12). Roosting owls were typically located or observed moving near (<152 m; 500 ft) or along streams (see Roost Site Characteristics).

Foraging owls crossed ridges and clearcuts when moving from one foraging area to another; however, forested habitat corridors were apparently selected as ties between habitat areas (see Corridors). Areas near peaks were avoided (Fig. 4), and flights (n=10), ranging from 182 to 303 m (600 to 1000 ft) in length, were observed across clearcuts.

However, topography (ridges) and the distribution or type of vegetation apparently influenced several owl's home range movements. For example, the nesting pair near Bee Tree Creek seldom ranged from low elevation, mixed evergreen forests and into higher elevation, montane forest (Figs. 14 and 15). In addition, the pair rarely crossed a ridge located on the northern periphery of their collective home range area. Similarly, extensive pole/medium tree stands (>2.6 km^2; 1 mi^2) or patchy expanses of brush/seedling/sapling tree stands were avoided by the Fourmile Creek pair (Figs. 8-10) and by owls on the Mosquito Creek study area (Figs. 11-16).

Topography and the distribution or type of vegetation has been shown to influence raptor home range size (Craighead and Craighead 1969; Forsman 1980, 1981).

Locations of major roosts, core areas, and nests. Major roosts were typically located within major foraging areas (core areas), but both could occur anywhere in the home range area (Figs. 19 and 20). Several major roosts, however, were located at distances greater than 1.2 km (.75 mi) from an owl's core area, within 242 m (800 ft) of heavily traveled roads, or within 121 m (400 ft) of clearcut boundaries.

Core habitat areas were intensive foraging use areas; however, mean core habitat area foraging use (percent frequency of occurrence) was not significantly greater than mean non-core habitat area foraging use, 63 percent (range=55-75 percent) and 37 percent (range=25-45 percent), respectively ($P>.50$; $t=.273$; $df=14$).

Nest site or suspected nest site locations also varied within home range boundaries. The Bee Tree Creek pair occupied a nest site located near the northern periphery of their collective home range and within 182 m (600 ft) of a commonly traveled, paved road (Fig. 20). The Sugarloaf Mountain nest site, in contrast, was centrally located within the male's (Harvey) home range boundary and within 303 m (100ft) of a heavily used logging road. Both nest sites were within 152 m (500 ft) of clearcuts, and they were located approximately 4.0 km (2.5 mi) apart. The suspected

nesting area at Fourmile Creek also was apparently centrally located within the pair's collective home range area (Fig. 19).

Variations were observed in the nesting status or success of individual owl pairs. The Fourmile Creek pair were not observed to nest or rear young during 1980 or 1981. The Bee Tree Creek pair, in contrast, attempted to nest and apparently deserted their nest, during spring 1981. The Western Foundation of Vertebrate Zoology, Los Angeles, California, identified eggshell fragments collected from the base of their nest tree as those of the spotted owl. The pair near Sugarloaf Mountain nested successfully during spring 1981 and reared one young.

Discussion: Nests at or close to centers of "territories" have been observed in falcons (Cade 1960) and jaegers (Pitelka et al. 1955). Cody (1974) indicated that centrally located nest sites were bioenergetically efficient. The occurrence of peripherally located nest sites may be attributed to the availability and distribution of suitable nest trees or to influences upon home range shape by topography, the distribution or type of vegetation, or the relative spatial distribution and territorial behavior of adjacent spotted owls.

Researchers have shown that a percentage of the available raptor nesting population typically refrain from nesting or breeding (Craighead and Craighead 1969; Southern 1970; Forsman 1976; U.S. Department of Interior 1979).

The Fourmile Creek pair's apparent non-nesting status was attributed to the relatively small area of preferred habitat within their collective home range boundaries (146.8 ha; 367 ac), stands which they intensively used for foraging (110 ha; 276 ac), and their collective home range size (503 ha; 1258 ac). The Bee Tree Creek pair, in comparison, had a total of 493 ha (1233 ac) of preferred habitat within their collective home range area, intensively used a stand greater than 280 ha (700 ac) in size for foraging, and had a collective home range area of 850 ha (2126 ac). Southern (1970) found that smaller, tawny owl "territories" were not viable as breeding "territories".

The Bee Tree Creek pair apparently deserted their nest after laying eggs. Desertion has been shown to be the principal cause of nest failures during the early stages of nesting in tawny owls (Southern 1970) and spotted owls (Forsman 1976). Southern (1970) found that desertion and the success in laying and hatching eggs by tawny owls was determined by prey availability. Similarly, Cave (1968) stated that the rate of desertion of eggs by the European kestrel, Falco tinnuculus, a species largely dependent on mammals, was highly correlated with a lack of food.

Distances traveled by owls within home range areas. Age and breeding status appeared to influence the distance over which spotted owls ranged during the breeding season. However, other factors may also influence the distances

which individuals range over an area (see Discussion on Home Range Size).

The dispersing immature male (Chopo) and the immature female (Suave) ranged approximately 10 km (6 mi) and 3.8 km (2.3 mi), respectively, as measured from edge to edge of their home range areas (Figs. 13 and 16). Limited observations on the immature female (Nieve) indicated that she ranged approximately 5 km (3 mi) from her initial point of capture, during a 10 day observation period (Fig. 2).

Two unpaired male owls (Uno and Bubba) traveled approximately 3.0 km (1.8 mi) and 3.6 km (2.2 mi), respectively, as measured from edge to edge of their home range areas (Figs. 7 and 12).

Adult pairs ranged a maximum of approximately 2.4 km (1.5 mi) from verified or suspected nest tree locations, and they ranged a maximum of 4.0 km (2.5 mi), as measured from edge to edge of their home range areas (Figs. 8-11, 14, and 15). Prior to the desertion of the nest, the Bee Tree Creek male ranged a maximum of approximately 1.6 km (1.0 mi) from the nest. The Bee Tree Creek male ranged a maximum of approximately 2.4 km (1.5 mi) from the nest after the pair had deserted the nest.

These patterns concur with observations on the movements of other raptor species by other researchers (Craighead and Craighead 1969; Southern 1970; Martin 1973). Forsman (1980, 1981) found similar patterns for spotted owls in Oregon.

Habitat Selection Analysis

Each major habitat type (e.g., seral stage 2, 3, and 4) occurred within each home range area and was available to each owl for use as foraging and roosting habitats. Chi-square and habitat preference analyses were only based on two habitat types (seral stage 3 and 4), because of the small number of occurrences (n=9) within seral stage 2; its inclusion would have violated the assumptions and sample size requirements of chi-square and habitat selection analyses (Cochran 1954; Neu et al. 1974; Zar 1974).

Seven owls were used in Chi-square and habitat selection analyses; the remainder were excluded because of an insufficient number of locations or a lack of a well defined home range area. Habitat use for owls excluded from the analyses are discussed. Similarly, sample size requirements precluded significance tests for montane forest, silviculturally treated, and inner-gorge areas. The use of these areas and of seral stage 2 are also discussed.

Foraging and roosting data were pooled for each owl because heterogeneity chi-square analyses indicated that the distribution of each owl's foraging and roosting locations were the same for each habitat type ($P>.05$). Chi-square goodness-of-fit analyses showed that the observed distribution of locations within these habitat types were significantly different for all owls, based on habitat availability

(Appendix D). Habitat preference techniques were used to determine if habitat types were preferentially selected or avoided, based on their availability (Appendix D). These analyses are summarized (Table 5) and discussed as follows.

Seral stage 4 (mature/old-growth tree stands). All owls used mature/old-growth tree stands for foraging and roosting significantly greater than expected ($P<.05$). Approximately 70 percent (n=266) of all foraging locations (n=378) and 89 percent (n=211) of all roosting locations (n=238) occurred within mature/old-growth tree stands.

Immature owls were consistently found in mature/old-growth stands as well. The immature male (Chopo) used mature/old-growth stands both for roosting and foraging, prior to his dispersal from the Sugarloaf Mountain area, but this owl was found in less "desirable" habitat after its dispersal from this area.

The Leary Creek male (Uno) used mature/old-growth stands more for roosting (61 percent; n=8 or 13) than foraging (21 percent; n=3 of 14). Small sample sizes may bias these results. Mature/old-growth tree stands occupied approximately 58 percent of his total home range area (home range=681 ha; 1702 ac).

Mature/old-growth tree stands in high elevation, montane forests occurred within the Bee Tree Creek pair's home range areas. The Bee Tree Creek pair never roosted and only foraged once within montane forest mature/old-growth stands. These higher elevation stands occupied approximately

six and seven percent of the male's and female's home range areas (home ranges: male=306 ha; 746 ac; female=670 ha; 1675 ac).

Silviculturally treated, mature/old-growth tree stands (Brush Flood Salvage and Bowl Salvage Sale areas) occurred within the Fourmile Creek pair's home range area (home ranges: male=272 ha; 681 ac; female=384 ha; 960 ac). These treated stands comprised approximately two percent of each owl's home range area, and some treated mature/old-growth stands appeared more suitable for roosting than foraging. For example, two of the female's preferred roost trees were located within a 16 ha (41 ac), less intensively treated mature/old-growth stand. The Fourmile Creek pair, however, were only observed to forage within this treated area on three occasions. The presence of an annual stream within 121 m (400 ft) of the roost trees may have been an overridding factor in roosting habitat selection.

Seral stage 3 (pole/medium tree stands). All owls used pole/medium tree stands for foraging and roosting significantly less than expected. Approximately 27 percent (n=103) of all foraging locations (n=378) and 11 percent (n=27) of all roosting locations (n=238) occurred within pole/medium tree stands.

As previously indicated, the dispersing male (Chopo was typically located within mature/old-growth tree stands prior to dispersing from the vicinity of Sugarloaf Mountai However, this owl later was consistently located within

pole/medium tree stands or within very marginal habitats, during and after his dispersal from this area. I hypothesized that the presence of spotted owl pairs along Mosquito Creek and southwest of Sims Mountain could have precluded this owl's use of more suitable habitats during his dispersal. The immature female (Nieve) was never located in these habitats.

The Leary Creek male (Uno) used pole/medium tree stands more for foraging (78 percent; n=11 of 14) than for roosting (39 percent; n=5 of 13). Small sample sizes may bias these results. Pole/medium tree stands occupied approximately 25 percent of his total home range area (681 ha; 1702 ac).

Pole/medium tree stands in high elevation, montane forests occurred within the Bee Tree Creek pair's home range areas. The male showed exclusive use of these montane stands, both for roosting (5 percent; n=1 of 20) and foraging (6 percent; n=4 of 68). Pole/medium tree stands within montane forests occupied approximately 1 and 18 percent of the female's and male's total home range areas (home ranges: female=670 ha; 1675 ac; male=306 ha; 764 ac).

Silviculturally treated pole/medium tree stands (Bowl Salvage and portions of Brush Flood Salvage sale areas) occurred within the Fourmile Creek pair's home range areas. These treated stands occupied approximately seven and eight percent of the male's and female's home range areas (home ranges: male= 272 ha; 681 ac; female=384 ha;

960 ac), and they received relatively low use, both for fo
aging (male=13 percent; n=7 of 54; female=3 percent; n=3 o
112) and roosting (female=9 percent; n=3 of 34). Preferr
roost trees were never located within these treated stands
The Bowl Salvage sale area was never used by either membe
of the pair.

Silviculturally treated pole/medium tree stands (Sims Ranch Units 11 and 14) also occurred within an immature female's (Suave) and an adult male's (Harvey) home range areas. These treated stands occupied approximately one and three percent of the female's and male's home rang areas (home ranges: female=670 ha; 1675 ac; male=190 ha; 475 ac). Unit 11 was infrequently used for foraging (male percent; n=1 or 29; female=4 percent; n=1 of 28) and never used for roosting. The owls did not revisit the stand, during a six month interval after an understory burn in Un 11. They never visited Unit 14.

Seral stage 2 (brush/seedling/sapling tree stands). Small sample sizes precluded statistical tests for this ha itat type. However, the low use of these stands suggested that the owls did not prefer this habitat type for foragin (2.3 percent; n=9 of 378) or roosting (roosts were never l cated in this habitat type).

Brush/seedling/sapling tree stands used for foragi were typically interspersed with open areas. Presumably, these open areas allowed the owls to reach prey on the ground.

Most foraging observations in brush/seedling/sapling tree stands (n=6) were attributed to the immature female, Suave. Both the total area (226 ha; 565 ac) and the percentage (40.3 percent) of the total home range area (560 ha; 1401 ac) occupied by brush/seedling/sapling tree stands were greater for this owl, compared to any other owl's home range area.

Owls were generally not observed flying across clearcut openings (10 observations) (see Corridors).

Habitat type codes. Sample size requirements, both for chi-square and habitat selection analyses, precluded significance tests for habitat type codes. Consequently, the relative selection of polygon habitat type codes was inferred by summarizing the distribution of foraging and roosting locations (n=484), by habitat type code (Fig. 21). Only locations which were described as being suitable for habitat selection analyses were used in this analysis.

Habitat type code 4B03B4 was the most frequently used for foraging (47.4 percent) and roosting (57.6 percent). Habitat type code 4B03B4 described timber stands characterized by an overstory of moderately dense (40-70 percent canopy closure), mature/old-growth trees which were subtended by a well developed understory of moderately dense (40-70 percent canopy closure), pole/medium sized trees. Douglas-fir was the predominant overstory tree species; the understory, a mixture of hardwoods, principally tanoak, in association with conifer seedlings and saplings.

Polygon characteristics are summarized (Table 6). Habitat type code 4B03B4 showed a disproportionately greater use, with respect to its availability. Timber stands lacking well developed understories or single storied stands (e.g., 4B000Z, 3B000Z, 3C100Z) showed relatively little use for foraging or roosting, indicating that the presence of some understory was required.

Although spotted owls exhibited some plasticity with respect to habitat use, as identified by habitat type codes, roosting habitat selection appeared less flexible than foraging habitat selection. A fewer number of habitat types (habitat type codes) were used for roosting (n=12, compared to foraging (n=19).

Minimum stand requirements. The use (percent frequency of occurrence) of different stand size intervals, both for discrete islands of mature/old-growth trees and for contiguous stands of mature/old-growth trees, are shown in Figs. 22 and 23, respectively. Only locations suitable for habitat selection analyses were used in this analysis. Locations were further described as: (A) occurrences in any habitat type (e.g., seral stage 2, 3, or 4), and (B) occurrences restricted to within mature/old-growth tree stands. If home range boundaries bisected timber stands, only those portions of the stands enclosed within home range boundaries were considered. Islands of timber were defined as timber stands whose size class characteristics differed from those

surrounding them (e.g., seral stage 4 surrounded by seral stage 2 or 3).

Spotted owls, both pairs (n=3) and individuals (n=8), most frequently used stands of mature/old-growth timber greater than 100 ha (250 ac) in size for foraging and roosting. These mature/old-growth stands averaged 202 ha (506 ac). (n=2; range=110-294 ha; 276-736 ac). Stands less than 110 ha (276 ac) appeared more suitable for roosting than foraging; however, preferred roost trees were not found in stands less than 16 ha (41 ac) in size.

Islands of mature/old-growth timber within home range areas of owl pairs averaged 32 ha (79 ac) (n=5; range= 8-110 ha; 20-276 ac), and those within individual home range areas averaged 64 ha (154 ac) (n=9; range=4-286 ha;11-714 ac). These averages were not significantly different (P>.50; t=.338; df=12).

Contiguous stands of mature/old-growth timber within home range areas of owl pairs averaged 48 ha (120 ac) (n=12; range=2-294 ha; 6-736 ac), and those within individual home range areas averaged 35 ha (87 ac) (n=38; range=1-294 ha; 1-736 ac). The average size of contiguous mature/old-growth tree stands was significantly greater for owl pairs (P<.001; t=25.893; df=46).

These data suggest that spotted owl pairs selectively chose mature/old-growth stands of a greater area, and that their minimum stand size requirement approached 120 ha (300 ac). Minimum stand size requirements, however, should

not be confused with minimum total area requirements for preferred habitats. The distinction is very important. For example, one mature/old-growth tree stand of 120 ha might not satisfy an owl's minimum total area requirements for its preferred habitat.

Discussion: Area relationships of preferred habitats have been presented, including the total area within home range boundaries and minimum stand size requirements. These relationships should be considered with respect to the spotted owl's requirements for maintenance (foraging and roosting) and reproduction. The total area of preferred habitats within home range boundaries appeared adequate for the owl's maintenance requirements, and the intensive use of large stands of these preferred habitats was related to the owl's minimum stand size requirements. A question related to their requirements for reproduction, however, remained unanswered: the minimum area of preferred habitat necessary for a pair to successfully breed and support a self-sustaining population.

The importance of size and isolation of forest tracts have been studied by researchers (Bond 1957; Moore and Hooper 1975; Galli et al. 1976; Whitcomb 1977). The results of their studies confirmed that the size of habitat areas strongly influenced species richness. Bond (1957) noted that richer (more mesic) forest habitats retained size sensitive species more easily than similar sized xeric tracts. Whitcomb et al. (1977) investigated the effects of

logging on the avifauna of mature forest ecosystems and noted that wide ranging raptors, such as the barred owl and red-tailed hawk, were residents of small forest tracts only if these areas were part of a larger forest system containing an area sufficient for their "territorial" requirements. Galli et al. (1976) noted that the red-shouldered hawk did not appear on patches less than 10 ha (40 ac) in size.

The theory of equilibrium biogeography suggested that species richness and biotic diversity increases as the area of suitable habitat increases (MacArthur and Wilson 1963; Diamond 1974; Wilson and Willis 1976; and others). Geometric designs derived from island biogeographic studies, have been suggested for the arrangements of habitat areas (Diamond 1974; Terborgh 1974; Diamond 1975; Wilson and Willis 1975) (Fig. 24). These designs would presumably enhance the suitability of habitat areas. They are briefly described: a larger habitat area is better than a smaller habitat area; a continuous habitat area should be circular, as opposed to linear; a continuous habitat area is better than a fragmented one; fragmented habitat areas should be close and equally spaced from each other; and corridors of suitable habitat should connect fragmented habitat areas.

Roost site characteristics. A total of 397 roost sites were triangulated of which 98 were physically located. Roost site characteristics are presented in Table 7; they are briefly described as follows.

Roosts were typically located in understory hardwood trees, which provided dense overhead and side closures, on the lower one-third of north to east facing slopes, and near water. Owls were selective in locating their roosts with respect to water. The average distance to water for roosting owls (142.1 m; 468.7 ft) was significantly less than the average distance to water for 100 randomly selected map locations ($P<.01$; $t=2.672$; $df=450$).

The preceeding characteristics combined to provide roost site temperatures which averaged 4.8 C (8.7 F) cooler than adjacent, vegetated areas lacking a tree canopy. Owl height above the ground showed a significant negative correlation with ambient air temperature ($r=-.289$; $P=.003$; $t=2.782$; $df=85$); thus, as temperatures increased, an owl's perch height decreased.

Most owls occasionally changed roost locations during the day. One of several closely spaced (<30 m; 100 ft) roost trees within a roost grove or another roost grove were then selected. This behavior occurred approximately 12 percent ($n=33$ of 398) of the time. Owls typically moved downslope when changing roost locations, and in doing so, they moved closer to or along stream channels or ephemeral draws. When changing roosts, owls traveled from 15 to 303 m (15 to 1000 ft).

Factor analysis: Factor analysis was useful in determining the relationships between macrohabitat variables at roost sites. Although 26 variables were entered in the

analysis, roost sites could be described by a nine factor model that accounted for 71.7 percent of the total variation in roost site variables (Table 8).

Factor names were derived from their highest correlations, and they include: Factor 1, the Roost Tree Height Factor, measures the occurrence of roost trees which are low in height, small in diameter, and provide significant canopy closures. These trees are likely to be selected as temperatures increase. Tanoak, as opposed to Douglas-fir, would be selected as a roost tree species; Factor 2, the Immediate Protection Factor, indicates that trees with dense overhead and lateral closures are likely to be selected as roost site temperatures increase. Percent slope tends to decrease at these roost sites; Factor 3, the North Aspect Factor, indicates that roost sites are likely to occur on north facing slopes, as opposed to east, as temperatures increase; Factor 4, the Distance to Water Factor, indicates that roost sites located on the lower one-third of south facing slopes, as opposed to north, are likely to be located near water. Percent slope tends to increase at these roost sites; Factor 5, the Tanoak Factor, indicates that tanoak, as opposed to canyon-live oak, would be selected as a roost tree species; Factor 6, the California Black Oak Factor, measures the low occurrence of California black oak as a roost tree species; Factor 7, the Canopy Closure Factor, measures the presence of high canopy closures at roost sites. Roost sites are likely to be located on the lower

one-third of south facing slopes; Factor 8, the Madrone Factor, measures the low occurrence of Pacific madrone as a roost tree species; Factor 9, the Dogwood Factor, measures the low occurrence of Pacific dogwood as a roost tree species.

Discussion: Factors 1, 2, 3, 4, and 7 support the hypothesis that thermoregulation is a major consideration in roost site selection by spotted owls (Gould 1974; Forsman 1976, 1980; Kertell 1977; Barrows and Barrows 1978; Barrows 1981). Roost site characteristics which provide cool microclimates are stressed. Forsman (1980, 1981) and Barrows and Barrows (1978) indicated that spotted owls may reduce their exposure to solar radiation during warm weather by roosting low in the understory (Factor 1). Roosts located near water (Factor 4) might tend to occur within steep, inner-gorge areas. This might explain a positive score for percent slope (PSLOPE) on Factor 4.

Factors 5, 6, 8, and 9, collectively accounted for a small portion of the total variation and were attributed to the relative abundance of these understory hardwood trees.

Special management areas. Corridors, riparian and inner-gorge areas, and edges were considered special management areas, because timber management activities may directly influence their quality. Consequently, I investigated the use of and relative importance of these areas to spotted owls.

Corridors: Spotted owls used travel corridors that varied in age, width, and origin. Timber management activities, particularly, produced stringers of timber on each study area, some of which were used as travel corridors. For example, the Fourmile Creek pair used existing pole/medium sized timber corridors ranging from 303 to 1600 m (1000 to 5280 ft) in width (n=30 observations). Five owls on the Mosquito Creek study area used existing dense mature/old-growth timber corridors ranging from 242 to 364 m (800 to 1200 ft) in width (n=41 observations).

Travel corridors were typically located on upland sites or along riparian areas. Corridors on upland sites commonly occurred along saddles; they were forested and used for moving from one drainage to another while foraging. Corridors along riparian areas were used for moving between foraging or roosting areas. Corridor total canopy closures typically exceeded 80 percent (overstory and understory combined); the overstory and understory each contributed greater than 40 percent to the total closure.

In summary, the owls apparently chose forested corridors when moving between habitat areas; flights across clearcuts were infrequent (n=10 observations).

Riparian and inner-gorge areas: Permanent and semi-permanent water sources and their associated vegetation were moderately used for foraging and roosting. A greater percentage (25.5 percent; n=213 of 835) of foraging locations occurred within 30.3 m (100 ft) of annual or perennial

streams, compared to roosting locations (15.2 percent; n=59 of 389).

Inner gorge areas were apparently not used for foraging or roosting, with respect to their availability. Although inner-gorge areas occupied from 9.6 to 24.5 percent of an individual owl's home range area, individual use of inner-gorge areas ranged from 8 to 39 percent for foraging or roosting.

Edges: Approximately 26 percent (n=219) of all foraging locations (n=835) were not considered during habitat selection analyses because of the proximity (<61 m; 200 ft) to habitat edges. However, a greater percentage of these locations were associated with low contrast edges (55 percent) (e.g. edges between pole/medium tree stands and mature/old-growth tree stands), compared to high contrast edges (45 percent) (e.g. edges between forest stands and clearcuts). Overall, a low percentage (11 percent; n=91 of 835) of all foraging locations occurred within 30.3 m (100 ft) of clearcut edges. Spotted owls, however, were observed to effectively detect and sieze prey from distances greater than 30.3 m, during several capture attempts.

Discussion on habitat selection. The subject of habitat selection has been reviewed by Lack (1933), Svardson (1949), Hilden (1965), and Cody (1974, 1981). Generally, proximate factors (those which elicit a response) and ultimate factors (those essential for survival) are considered mechanisms for habitat selection. Bird species have been

shown to respond to the following proximate factors: structural configuration of vegetation (Kilgore 1977; Franzreb 1977); topography (Craighead and Craighead 1969); differences in food supply within habitat areas (Root 1967; Balda 1969; Cody 1981); competitors (Cody 1974; Terborgh 1975); and nest site availability (Haartman 1956, 1957). Requirements for food and protection from predators or adverse environmental conditions are considered ultimate factors (Hilden 1965).

The infrequent use of certain habitat areas (e.g. montane forests, clearcuts, single-layered stands) was attributed to the structural configuration of the vegetation. Vegetation structure probably affected the following: the degree of protection from predators; access to prey; the availability of suitable roosting, foraging, and nesting substrates; microclimates within forest stands; or prey diversity and abundance.

Foraging use within a thinned stand was observed to cease following a burn in the understory. The resultant lack of use was attributed to the changes in ground cover and its resultant influence upon prey populations. The abundance and distribution of small mammals have been related to several measures of habitat structure, including foliage height diversity, ground cover, stem density, and stem basal area (M'Closkey 1975; M'Closkey and Fieldwick 1975; Dueser and Shugart 1978; Holbrook 1978).

Several researchers have considered the response of small mammal populations before and after burning of habitat areas (Moore 1940; Tevis 1956a; Tester 1965; Hooven 1969; Gashwiler 1970; Fala 1975) and to clearcutting (Gashwiler 1959, 1970; Hooven 1969; Kirkland 1977; Martell and Radvanyi 1977). Burning or clearcutting selectively reduced small mammal populations. The immediate effects of fire upon small mammals were variable and dependent upon the availability of shelter during a fire, the fire's intensity, and the reduction of ground cover. The recovery after burning or clearcutting was rapid for some species, notably deer mice, Peromyscus maniculatus. However, Cook (1959) reported that some mammals required at least one year's accumulation of mulch after a fire before population recovery. Lubina (1978) showed that fire caused a reduction of shrub cover and a subsequent decrease in the numbers of dusky-footed woodrats, Neotoma fuscipes. Tevis (1956b) found that logging caused an increase in the numbers of some mammal species, including the dusky-footed woodrat.

The results also suggested that riparian and inner-gorge areas were not intensively used for foraging or roosting. The importance of the microclimates produced by these areas, however, needs emphasizing as they apparently influenced rosting habitat selection at distances greater than 30 m (100 ft); the distance used in describing inner-gorge areas.

Thomas (1979) indicated that riparian areas provide cool microclimates and suggested that they may serve as connections between forested habitats for dispersing wildlife species. The dispersing immature male owl (Chopo) appeared to use forested riparian habitats along Mosquito Creek, during his dispersal from the Sugarloaf Mountain area. Wauer (1977) noted bird species use of riparian corridors. Willis (1974) and MacClintock et al. (1977) confirmed the importance of corridors connecting fragmented forest tracts to reduce their isolation and to maintain biotic diversity within these areas.

It appeared that habitat edges, both low contrast and high contrast edges, were relatively low use foraging areas; however, the possibility existed that spotted owls could effectively hunt (forage) along edges at distances greater than I observed (30 m; 100 ft).

Food Habits

Food habit information from owl castings collected between July 1980 and August 1981 is summarized for nine spotted owls (Table 9). Mammals comprised the greatest percentage (91.3 percent) of all prey taken (n=240). Of these, terrestrial or semi-terrestrial mammals and arboreal or semi-arboreal mammals comprised approximately 71 percent and 20 percent of all prey taken, respectively. The dusky-footed woodrat, predominated the diet and comprised approxi-

mately 45 percent of all prey taken and 85 percent of the total biomass consumed (n=343,689 g).

No attempt was made to determine seasonal and sexual variations in prey utilization, because of the time intervals between when pellets were casted and they were collected.

Discussion: The northern flying squirrel, Glaucomys sabrinus is considered the prevalent prey species, both in numbers and biomass, in the spotted owl's diet throughout most of Oregon (Marshall 1942; Forsman 1976, 1980). However, Forsman (1976) reported that dusky-footed woodrats or bushy-tailed woodrats, Neotoma cinerea, replaced the northern flying squirrel as the principal prey species, both in numbers and biomass, in some southern Oregon locales. Further, several researchers have reported the occurrence of dusky-footed woodrats as the major prey item in the spotted owl's diet in northern California (Barrows and Barrows 1977; Whisler and Horn 1977; Barrows 1980).

Dusky-footed woodrats are characterized as nocturnal and capable of occupying a variety of habitat types (Ingles 1965; Maser et al. 1981). Raphael et al. (1981) reported that dusky-footed woodrats were more abundant in mature and over-mature Douglas-fir stands, compared to sawtimber stands, during a preliminary study. The term sawtimber is analogous with seral stage 3 , while both mature and over-mature are analogous with seral stage 4. Their preliminary results provide evidence for the observed patterns of forag-

ing habitat selection and prey species selection, because several of their mammal trapping plots occurred within five of the nine owl home range areas used for this analysis.

Maser and Brodie (1966) suggested that prey selection was influenced by: the habitat types which a predator hunted; the normal activity period (diurnal vs. nocturnal), the maturity, or inherent fluctuations in local populations of prey species; and the time of year. Royama (1970) added that hunting behavior and prey selection were influenced by prey conspicuousness, differences in the microhabitats of prey species, and the effects of alternative prey and of prey size and handling time upon profitability (as measured by biomass). My results suggested that the profitability of prey species were a determining factor in prey selection. I inferred that habitat type was also an influential factor.

Microhabitat Analysis

Habitat Characteristics

Spotted owl habitat characteristics were investigated by measuring a total of 496, .04 ha (0.1 ac) circular plots (Table 10). Three major habitat areas (roosting, core and non-core areas) were described independently, collectively, and by sex (Appendix E). Mean values for selected habitat characteristics are compared for each area (Table

2. Canopy closure. Hardwood and conifer trees combined to form multilayered stands (two or more layers) which provided dense canopy closures. Canopy closures decreased from roost to non-core habitat areas; core habitat areas were intermediate.

3. Decadence. It was my subjective impression that most stands were generally not characterized as being highly decadent. The presence of older conifers (250+ years) was common; however their condition was generally good, as measured by the presence of pointed crowns and the absence of excessive broken tops, windthrow, or conks. The condition of the hardwood component varied from decadent to thrifty, depending on their age. It is important to indicate that many other habitat characteristics may be associated with stand age (decadence), which may influence spotted owl habitat selection, were not investigated by this study.

4. Shrub layers. Tanoak was consistently recorded as the dominant species in all shrub layer height intervals (Tables 1-12 in Appendix E).

5. Ground cover. Small tress (<10.0 cm (4.0 in) DBH), shrubs, and herbaceous vegetation comprised the vegetative ground cover. Small

tree ground cover decreased from roost habitat to non-core habitat areas; core area habitats were intermediate. Herbaceous vegetation generally increased from roost habitat to non-core habitat areas; core habitat areas were intermediate. Shrub ground cover was generally lowest in intensively used foraging habitats (core areas), greatest in less intensively used foraging habitats (non-core areas), and intermediate in roost habitat areas.

6. Debris. Litter (organic matter, and branches <2.5 cm (1 in) in diameter), small logs (<30.0 cm (12.0 in) diameter), and large logs (>30.0 cm diameter) comprised debris on the forest floor. Small log ground cover generally increased from non-core habitat to roost habitat areas; core habitat areas were intermediate. Large log ground cover generally increased from core habitat to non-core habitat areas; roost habitat areas were intermediate.

7. Physiography (aspect and elevation). All habitat areas were generally located on north to east facing slopes over a wide elevational range. Within a specific area, however, roost, non-core, and core habitats were typi-

cally located at lower, intermediate, and higher elevations, respectively.

8. Snag characteristics. Douglas-fir snags were the most frequently encountered (50.7 percent; n=502 of 991) snag species (Appendix F). Douglas-fir snags were typically characterized as occurring in the following stages: composed of sound wood (73.9 percent), with intact bark (54.8 percent) and top (46.8 percent), and lacking any live foliage (96.0 percent) (Appendix F). Douglas-fir snags averaged 32.5 cm (13.0 in) DBH (range=10-197.5 cm; 4-79 in) and 11.7 m (38.5 ft) in height (range=2-63 m; 6-208 ft) (Appendix 18). It is important to note that decadence levels appearing in Table 11 and in Appendix E (Tables 1-12) reflect decadent characteristics for snags.

In summary, size class, canopy closure, and stand structure (multilayered) information from these results confirmed habitat type mapping information (habitat type code 4B03B4), which described intensively used spotted owl foraging and roosting areas.

Analysis of variance (ANOVA). Mean values for all ground cover, physiographic, and tree characteristics (density, basal area, height, and DBH by DBH interval) described in Appendix C (Table 2) were tested for equality by a series

of univariate ANOVA's. Analyses were based on a combination of sex and habitat area. Variables for which significant differences were detected, where specific differences occurred, and the source of variation are summarized (Table 12). The comparisons revealed the following:

1. Stem density and basal area. Most differences were noted within intermediate and large size classes. Roost habitats for females showed a significant decrease in stem density and basal area of trees in smaller size classes. This decrease was accompanied by an increase in the density and basal area of trees with larger diameters (>90.0 cm; 36.0 in). Non-core habitat areas, particulary those of males, showed a decrease in stem basal area and density, both for the intermediate and large size classes and for all DBH intervals combined. Variations in stem density and basal area were attributed to significant differences between the sexes and between habitat areas.
2. Canopy closure. A significant reduction in canopy closure was observed for each sex within non-core habitat areas, compared to core habitat and roost habitat areas. Core habitat and roost habitat canopy closures were not significantly different. Variations

in canopy closure were totally attributed to significant differences between habitat areas. The multilayered character of stands generally remained comparable throughout all habitat areas.

3. Ground cover. There was a significant increase in herbaceous ground cover within non-core habitat areas for females and in shrub cover within core habitat areas for males. These variations were totally attributed to differences between habitat areas. A decrease in small log ground cover within all habitat areas for males was significant and totally attributed to differences between the sexes.

4. Physiography (aspect and elevation). The tendency for roost locations not to occur on south facing slopes was significant and totally attributed to differences between habitat areas. A decrease in elevation at roost habitat areas and between non- core habitats for each sex was significant and attributed both to differences between the sexes and between habitat areas, in each instance.

Discriminant analysis. Discriminant analysis was useful in assessing which habitat characteristics (structural, vegetative, or physiographic) differentiated between

habitat use areas (Figs. 25-33). Habitat characteristics which best differentiated among discriminant groups (habitat use areas) are shown as gradients (low to high) along discriminant axes. Subsets of variables entered into discriminant analyses are shown in Appendix G.

Differences between the sexes: Observed differences between the sexes are described as follows:

1. Habitat areas combined. A subset of 32 of the original 230 variables were entered into discriminant analysis. One discriminant function resulted, which explained 19.0 percent of the total variation between the sexes and was characterized by: high stand decadence, basal area of live Douglas-fir, total basal area and hardwood basal area in the 27.5-52.3 cm (11.0-20.9 in) DBH interval, stem density (California black oak and Oregon white oak) and basal area (canyon-live oak) of small understory hardwoods, and elevation (Fig. 25). Redundant variables not included in the analyses, because of their high correlations with the basal area of Douglas-fir, included: total conifer basal area (r=.93), total basal area (r=.83) for all DBH intervals combined, and large conifer (>90.0 cm (36.0) in DBH) density (r=.77) and basal area (r=.87).

Although separation of the sexes along the single discriminant function was highly significant (P=.000; t=9.667; df=450), the distinction between the groups was low, because only 19 percent of the total variation was explained. The power of the discriminating variables was moderately high; 77.8 percent of all plots were correctly classified. Classification success exceeded the a priori probability of 50 percent.

2. Roost habitat area. A subset of 30 of the original 230 variables were entered into discriminant analysis. One discriminant function resulted, which explained 36.6 percent of the total variation between the sexes in roost habitats (Fig. 26). The single discriminant function was characterized by: moderate stand decadence, snag density in the 10.0-12.3 cm (4.0-4.9 in) DBH interval, and the total basal area of live tanoak trees to a lesser extent. Hardwood tree density in the 12.5-27.3 cm (5.0-10.9 in) DBH interval was excluded from the analysis, because of its high correlation (r=.68) with the basal area of live tanoak trees.

Separation between the sexes along the single discriminant function was highly sig-

nificant (P<.01; t=2.934; df=48). A moderately high percentage (76 percent) of all plots were correctly classified, exceeding the a priori probability of 50 percent.

3. Core habitat areas. A subset of 61 of the original 230 variables were entered into discriminant analysis. A single discriminant function resulted, which explained 31.1 percent of the total variation between the sexes in core habitat areas (Fig. 27). The single function was described by: large conifer (>90.0 cm (36.0 in) DBH) density, live tree density (California black oak, tanoak, and canyon-live oak) and basal area (Oregon white oak) of understory hardwood trees, and high stand decadence. Variables not included in the analysis because of their high correlation with live tanoak tree density, included: hardwood tree density (r=.72) and basal area (r=.74) in the 12.3-27.3 cm (5.0-10.9 in) DBH interval, and total hardwood tree density (r=.77) for all DBH intervals combined.

Separation between the sexes along the discriminant function was highly significant (P<.001; t=7.832; df=350). Discriminant analysis correctly classified a moderately high percentage (74.6 percent) of all plots, ex-

ceeding the a priori probability of 50 percent.

4. Non-core habitat areas. A subset of 36 of the original 230 variables were entered into discriminant analysis. One discriminant function resulted, which explained 99.9 percent of the total variation between the sexes in non-core habitat areas (Fig. 28). This function was best described by: snag density (Douglas-fir and madrone), total basal area in the 52.3-89.8 cm (21.0-35.9 in) DBH interval, small diameter hardwood basal area, to a lesser extent.

   Separation between the sexes was highly significant ($P<.001$; $t=3.804$; $df=30$). All plots (100 percent) were correctly classified, exceeding the a priori probability of 50 percent.

5. Summary. The preceeding discriminant analyses are summarized as follows:

   a. The distinction between the sexes, as measured by the amount of variation which could be explained, ranged from 19.0 to 99.9 percent. The distinction was least when all habitat areas were combined, intermediate in roosting and core habitat areas, and greatest in non-core habitat areas.

b. The power of the discriminating variables to distinguish between the sexes, however, remained high, resulting in significant differences between the sexes in all analyses.

c. Discriminant analysis was highly successful in correctly classifying a large percentage (range=74.6-100 percent) of all plots, exceeding the a priori probability (50 percent) in every instance.

d. Variables which generally discriminated between the sexes included: stand decadence, density and basal area of trees in intermediate (12.5-27.3 cm (5.0-10.9 in) DBH) and large (>90.0 cm (36.0 in) DBH) size classes, and elevation to a lesser extent.

e. Forest stands used by females, particularly for intensive foraging use, were generally characterized as: being in a greater state of decadence and, therefore, presumably more open; having a decrease in the density and basal area of smaller diameter (12.5-27.3 cm; 5.0-10.9 in) trees, which was accompanied by an increase in the density and basal area of larger diameter (>90.0 cm; 36.0 in) trees; and occurring at lower elevations. Males, in contrast, showed the opposite trends in each category above.

Differences between habitat areas: Observed differences between habitat areas are described as follows:

1. Females. A subset of 38 of the original 230 variables were entered into discriminant analysis. Two discriminant function resulted which explained 81.8 percent of the total variation between habitat areas for females (Fig. 29). The first discriminant function (DF-I), which accounted for 68.7 percent of the initial total variation, was described by: canopy closure, herbaceous ground cover, and live Douglas-fir total basal area. Variables removed from the analysis, as they were highly correlated with live Douglas-fir total basal area included: total live tree density (r=.83), total conifer tree basal area (r=.87),total conifer tree density (r=.80) in the greater than 90.0 cm (36.0 in) DBH interval, and total live tree basal area (all DBH inervals combined). The second discriminant function (DF-II) accounted for 31.3 percent of the initial total variation and was described by: elevation and hardwood tree density in the 12.5-27.3 cm (5.0-10.9 in) DBH interval.

All habitat areas were significantly separated along one or both discriminant axes. Highly significant separations along DF-I occurred between: roost and non-core habitat areas ($P<.001$; $t=3.268$; $df=39$); and core and non-core-habitat areas ($P<.005$; $t=3.195$; $df=34$). Similarly, the distinctions between roost and core habitats ($P<.001$; $t=4.761$; $df=29$) and between core and non-core habitat areas ($P<.001$; $t=7.492$; $df=34$) along DF-II were highly significant.

Group separation, as described by the percentage of plots correctly classified, was high (mean=84.0 percent; range=73.0-94.7 percent); exceeding the a priori probability of approximately 33 percent.

2. Females (core vs. non-core habitats). A total of 35 of the original 230 variables were selected to enter into discriminant analysis. One discriminant function resulted, which explained 82.1 percent of the total variation between core and non-core habitat areas used by females (Fig. 30). The discriminant function was described by: total live tanoak density, large tree (>90.0 cm (36.0 in) DBH) total basal area, high stand decadence, conifer density and snag basal area in the

27.5-52.3 cm (11.0-20.9 in) DBH interval, elevation, and canopy closure. Hardwood density in the 12.5-27.3 cm (5.0-10.9 in) DBH interval was excluded from the analysis because of its correlation with total live tanoak density.

Separation between core and non-core habitats along the discriminant axis was highly significant ($P<.001$; $t=3.953$; $df=39$). The discriminating power of the variables was high (mean=97.4 percent of all plots correctly classified; range=83.8-100.0 percent). Classification success exceeded the a priori probability of approximately 50 percent.

3. Males. A subset of 44 of the original 230 variables were selected. Two discriminant functions resulted, which explained 82.9 percent of the total variation in habitat areas used by males (Fig. 31). The first discriminanat function (DF-I), which explained 56.8 percent of the initial total variation, was characterized by: large conifer (>90.0 cm (36.0 in) DBH) basal area, and by canopy closure. The second discriminant function explained 43.2 percent of the initial total variation and was described by: elevation, and aspect (south).

Significant distinctions occurred between habitat areas on both discriminant axes. All habitat areas were distinctly separated along DF-I: roost and core habitats ($P<.02$; $t=2.267$; $df=55$), roost and non-core habitats ($P<.001$; $t=4.394$; $df=56$), and core and non-core habitats ($P<.001$; $t=3.186$; $df=58$). Significant separations of habitat areas along DF-II included: roost and core habitats ($P<.001$; $t=4.992$; $df=55$), core and non-core habitats ($P<.001$; $t=4.695$; $df=58$). A high percentage (mean=82.9 percent; range= 74.7-92.8 percent) of all plots were correctly classified, exceeding the a priori probability of 33 percent.

4. Males (core vs. non-core habitats). A subset of 45 of the original 230 variables were selected. A single discriminant function resulted which explained 69 percent of the total variation between core and non-core areas used by males (Fig. 32). The discriminant function was described by: large logs (diameter=>30 cm; 12 in) on the forest floor, total tree density (all DBH intervals combined), and canopy closure. Variables excluded from the analysis, because they were highly correlated with total tree density,

included: the density (r=.85 and basal area (r=.79) of trees in the 12.5-27.3 cm (5.0-10.9 in) DBH interval, and total tree density (r=.75) and basal area (r=.70) in the 10.0-12.3 cm (4.0-4.9 in) DBH interval.

The distinction between male core and non-core areas was highly significant ($P<.001$; $t=4.304$; $df=56$). Variables describing the discriminant axis were highly successful in discriminating between habitat areas. Discriminant analysis correctly classified an average of 92.6 percent (range= 84.4-98.2 percent) of all plots, exceeding the a priori probability of approximately 50 percent.

5. Sexes combined. A subset of 27 of the original 230 variables were selected to enter into discriminant analyses. Two discriminant functions were derived which accounted for 43 percent of the total variation between all habitat areas (Fig. 33). The first discriminant function (DF-I) accounted for 74.3 percent of the initial total variation and was described by: canopy closure, aspect (south), live tanoak density, total basal area, and herbaceous ground cover. Tanoak density was highly correlated with hardwood

tree density (r=.65) in the 12.5-27.3 cm (5.0-10.9 in) DBH interval. Total basal area was highly correlated with large conifer (>90.0 cm (36.0 in) DBH) basal area (r=.80) and density (r=.90). These highly correlated variables were excluded from the analysis. The second discriminant function (DF-II) accounted for 26 percent of the initial total variation and was described by elevation and aspect.

Significant separation occurred between all group means on DF-1: roost and core ($P<.01$; $t=2.737$; $df=92$); roost and non-core ($P<.001$; $t=4.596$; $df=96$); core and non-core ($P<.05$; $t=2.111$; $df=90$). The separation between roost and core habitat areas ($P<.01$; $t=2.687$; $df=92$) and between core and non-core habitat areas ($P<.005$; $t=2.869$; $df=90$) on DF-II were highly significant. A moderate percentage (mean=65.8 percent; range=59.7-72.5 percent) of all plots were correctly classified, exceeding the a priori probability of approximately 33 percent.

6. Summary. The preceding discriminant analyses are summarized as follows:

a. The distinction between habitat areas, as described by the amount of variation which

could be explained, generally was high (range=68.7-82.9 percent).

b. Similarly, the discriminatory power of the variables was high, resulting in significant differences between habitat areas along one or both discriminant function(s) in all analyses.

c. The analyses generally were highly successful in correctly classifying a large percentage (range=56.8-97.6 percent) of all plots, exceeding the a priori probability of approximately 33 or 50 percent in each instance.

d. Variables which consistently discriminated between habitat areas included: canopy closure, density and basal area of trees in small diameter (12.5-27.3 cm; 5.0-10.0 in) and in large diameter (>90.0 cm; 36.0 in) size classes, elevation, aspect, and to a lesser extent decadence and herbaceous ground cover.

e. Multilayered forest stands were important features of intensively used habitat areas.

f. Forest stands used for roosting were characterized as follows: being multilayered; with high total canopy closures, increased large conifer density and basal area, and low

herbaceous ground cover; occurred at lower elevations and on north facing slopes; and had a greater state of decadence than other habitat areas.

g. Forest stands which were intensively used for foraging (core areas) were similar in structure. However, they were characterized as follows: being intermediate in decadence, canopy closure, stem density and basal area, herbaceous ground cover; and occurred at higher elevation than roost or non-core areas.

h. Forest stands receiving low foraging use (non-core areas) were described by: further decreases in canopy closure, conifer stem density and basal area, and hardwood stem density; and by increased herbaceous cover.

Discussion: Home range information showed that areas near suspected and verified nest sites received intensive foraging and roosting use by an owl pair. Members of owl pairs were often simultaneously observed foraging in close proximity (<61 m; 200 ft) to each other within the same forest stand for several hours; thus, apparently in direct competition with each other. Multivariate analyses, however, suggested differential niche (habitat) utilization by the sexes within their foraging habitats, both core and non-core areas.

I inferred that the observed patterns are probably based on sexual dimorphism. Earhart and Johnson (1970) described the extent of size dimorphism in North American owl species and concluded that female owls had greater wing loading and might, therefore, be less maneuverable than males. They also noted that the extent of sexual dimorphism in spotted owls was expressed to a lesser degree, compared to other North American owls, including members of the genus Strix, Glaucidium, and Aegolis. Selander (1966) and Earhart and Johnson (1970) hypothesized that the difference in size between the sexes in raptors would permit differential niche (habitat) utilization; thus, allowing the sexes to explore different habitat areas and reducing intersexual competition as a result. My results clearly illustrate this concept. Significant reductions in the amount of shrub cover, tree density and basal area of small hardwoods, and increases in the decadence of foraging habitats used by females would presumably enhance the female's maneuverability in these forest stands. The female's sensitivity to changes in forest structure are further illustrated by noting that significant differences between the sexes in core areas were based on relatively small changes in shrub cover (<3 percent) and hardwood tree density (<5 stems/ha; 2 stems/ac) in the 12.527.3 cm (5.0-10.9 in) DBH interval.

Intersexual competition was also effectively reduced by temporal shifts in habitat use and by foraging in different areas or strata (elevation). Statistical analyses show

ed that elevation was a significant factor in separating habitat use by the sexes; the differences being subtle (<61 m; 200 ft). Selander (1966) and Cody (1974) have discussed these and other methods for reducing intersexual competition for food.

The results also clearly indicated that foraging and roosting habitat selection by spotted owls were constrained by the physical structure and physiogonomy of the environment. Roosting habiat selection, particularly, appeared more constrained along environmental gradients of canopy closure, tree density and basal area, aspect, and elevation, compared to foraging habitat selection. Temperatures would be reduced and cool microclimates provided at roosts having increased canopy closures and tree density; and by being positioned on north slopes or lower elevations (presumably near water). The basis for differences between habitat areas was greatest between roost and non-core habitat areas (e.g., difference in canopy closure and large conifer density was 23 percent and 22.5 stems/ha (9 stems/ac), respectively) and least between roost and core habitat areas (e.g., difference in canopy closure and large conifer density was 5 percent and approximately 15 stems/ha (6 stems/ac), respectively).

The suitability of foraging habitats was also determined by the extent of shrub cover. The amount and distribution of ground cover has been shown to have a greater effect in influencing the suitability of habitat areas for use

as foraging site by hawks and owls, than prey abundance (Southern and Lowe 1968; Craighead and Craighead 1969; Wakeley 1978; Baker and Brooks 1981; Bechard 1982). Raptors spent a greater time or had greater hunting success by hunting in habitat areas with sparser ground cover than in areas with denser ground cover which had greater densities of prey populations. Spotted owls were apparently affected by habitat structure, as are many other birds (Cody 1968; Anderson and Shugart 1974; Whitmore 1977; Noon 1981; and others).

SUMMARY AND CONCLUSIONS

Twelve northern spotted owls were observed on the Six Rivers National Forest, Humboldt County, California, 9 July 1980-24 August 1981. Ten owls were radio-tracked and detailed habitat measurements were collected primarily during the breeding season (February-October). These data further refine knowledge concerning the spotted owl's basic habitat requirements and factors governing habitat selection, prerequisites for the effective management of this species.

Home Range Characteristics

Spotted owl pairs occupied large home range areas (mean=676.8 ha; 1692 ac) in which stands of mature/old-growth timber were the predominant vegetation. An average of 320 ha (800 ac) of this habitat was located within an owl pair's collective home range area. I concluded that these area requirements were probably a minimum because of the relatively short observation periods for most owls. Home range sizes of immature owls were comparable to those of adults; however, a dispersing immature male wandered over an extensive area (2319 ha; 5799 ac).

Habitat quality, both its availability and patchiness, was a factor in determining home range size. Specifically, the quality of preferred habitats (mature/old-growth tree stands) and of avoided habitats (brush/seedling/sapling tree stands). I concluded that home range size increased as the availability of less desirable habitats or the patchiness of preferred habitats increased, because either the owl's minimum stand size or the minimum total area requirements for its preferred habitats had not been met. Many other factors, however, were discussed which have been demonstrated to influence home range size, including prey availability, and an individual's sex or age.

Habitat Selection

Stands of mature/old-growth timber (seral stage 4) within the mixed evergreen forest (Sawyer et al. 1977) were the major habitat type preferred by spotted owls for foraging and roosting. Stands characterized by habitat type code 4B03B4, specifically, were intensively used for foraging and roosting. This habitat type code described stands with moderately dense (40-70 percent canopy closure) overstories of mature/old-growth conifers (Douglas-fir), which were subtended by a moderately dense (40-70 percent canopy closure) mixture of pole/medium sized hardwood trees (tanoak, primarily, occurring in combination with Pacific madrone, canyon-live oak, California black oak, and Oregon white oak). In-

tensive habitat measurements confirmed this mapping information.

Minimum stand size requirements for preferred habitat areas approached 120 ha (300 ac). Smaller habitat areas appeared to be more suitable for roosting than foraging. Minimum stand size requirements should not be confused with minimum total area requirements; an area approaching 400 ha (1000 ac) for an owl pair.

Non-preferred (avoided) habitats included: pole/medium tree stands; brush/seedling/sapling tree stands; montane forests adjacent to mixed evergreen forests; single-layered stands; and silviculturally treated areas which extensively altered the habitat stucture (e.g., clearcuts, heavy thinning, or heavy sanitation or salvage sales). Mature/old-growth patches within a salvage sale area, however, appeared more suitable for roosting than foraging. Foraging owls were not immediately observed (within six months) to revisit a thinned stand, following an understory burn.

The effects of physiographic features upon owl movements within home range areas were variable. Ridgelines were not intensively used for foraging and roosting; however, forested saddles along ridgelines facilitated owl movements from one drainage to another. Movements within home range areas appeared restricted by extensive changes in habitat type or the patchy distribution of non-preferred habitats. Owls typically moved from one area to another by

moving through forested habitat ties, as opposed to flying across extensive unforested areas (2.6 km^2; 1 mi^2).

Major roosting and foraging areas were typically located near suspected or verified nest locations. Owl pairs ranged a maximum of 2.4 km (1.5 mi) from active nests.

Thermoregulation was a major consideration in roost site selection by spotted owls. A combination of structural (canopy closure) and physiographic (aspect, distance to water) habitat characteristics or an owl's behavior (selection of slope position or exposure), collectively or independently, were influential in roosting habitat selection. Owls selectively chose roosts located near water (mean=142.1 m; 468.7 ft).

Forested corridors facilitated movements between intensively used habitat areas and were located along riparian areas or upland sites (saddles). Structurally, corridors were multilayered and dense (>80 percent canopy closure). Spotted owls did not show a disproportionate use of riparian and inner-gorge areas, with respect to their availability. However, these areas were significant in providing cool microclimates for roosting and nesting owls and in acting as corridors or habitat ties for foraging, roosting, and dispersing owls.

Food Habits

Spotted owls apparently located dusky-footed woodrats, the primary prey species, within the center of mature/old-growth forest stands.

Habitat Characterisitcs

Differential niche (habitat) utilization, probably based on sexual dimorphism, and specific habitat selection by spotted owls were hypothesized. Differences in the maneuverability of each sex, coupled with differences in stand structure (stand decadence, tree density and basal area, shrub cover) and physiography (elevation) resulted in differential habitat use by the sexes. Intraspecific competition for food was presumably reduced as a result.

The use of specific habitat areas (roost, core, and non-core habitat areas) was distinguished by differences in stand structure (canopy closure, tree density and basal area), and physiography (aspect and elevation) of each area. Prey accessability or abundance may have been major factors influencing foraging habitat selection.

However, the distinction in habitat selection between the sexes and between habitat areas, specifically between roost and core areas, were attributed to subtle differences in habitat structure or physiography. This suggested that spotted owls are specific in their habitat re-

quirements. These specific habitat requirements may partially explain the spotted owl's large area requirements, both the home range area and the area for preferred habitats; because large areas would be required to find structurally suitable foraging and roosting habitats.

I concluded, however, that roosting habitat requirements were less flexible, compared to foraging, and that habitat structure, vegetation, and physiography were major factors influencing spotted owl habitat selection. The low use of pole/medium tree stands, brush/seedling/sapling tree stands, montane forests, and some silviculturally treated areas clearly illustrated the influence of habitat structure upon habitat selection.

In conclusion, habitat suitability was partially determined by a complex interaction of factors including: habitat selection by the sexes; and differences in the structure, vegetation, and physiography of habitat areas. Specific spotted owl habitat management (e.g., management for differences between the sexes), however, may be constrained by the ability of current silvicultural methods to entirely accommodate subtle structural differences between habitat areas.

MANAGEMENT RECOMMENDATIONS

Spotted Owl Management Areas (SOMA's)

SOMA's have been defined and the criteria used to confirm them have been described by recent U.S. Forest Service guideline (Amendment No. 2, January 21, 1981, Appendix 8 - Criteria for maintaining viable populations of spotted owls). Detailed SOMA habitat descriptions, however, have been lacking. These data, in conjunction with past studies, indicate that SOMA's may be further described as follows.

Area Relationships

To facilitate movements from one area to another by dispersing young and by foraging or roosting owls, corridors of structurally suitable habitat should be maintained which serve to connect:

a. SOMA's, especially if SOMA's are peripheral or if they contain a single "territory".
b. Each "territory" within a SOMA.
c. Mature/old-growth tree stands within each "territory".

Corridors are likely to occur along saddles on ridgelines or along riparian areas. Desirable corridor characteristics include:

a. Total canopy closures in excess of 80 percent with the overstory and the understory each contributing greater than 40 percent.

b. A width greater than 242 m (800 ft).

c. A multilayered structure (two or more layers).

Each "territory" within a SOMA should consist of the following:

a. A 120 ha (300 ac) core area which contains a verified or suspected nest site.

1). A diligent attempt should be made to identify and verify the nesting grove prior to delineating a "territory", because nesting groves are focal roosting and foraging areas.

2). Verified or suspected nest sites should be centrally located, or nearly so, as determined by habitat availability.

3). Nest placement and nesting success should be monitored annually to ensure that core areas are adequately located and that "territories" are viable.

b. An additional 280 ha (700 ac) of suitable foraging, roosting, dispersal, and core replacements in one to two parcels.

c. Mature/old-growth tree stands should comprise 70-100 percent of the total "territory" area.

d. Pole/medium tree stands should comprise 0-30 percent of the total "territory" area.

e. Brush/seedling/sapling tree stands should comprise no more than two percent of the total "territory" area, based on percent use for this habitat type.

Characteristics, Size, and Arrangement of Stands

Stand characteristics. Data for the development of silvicultural prescriptions are shown (Appendix E). Specific recommendations include the following:

a. It is important to maintain roost habitat characteristics because roosting habitat selection appears less flexible, compared to foraging habitat selection. Roost habitat characteristics should approximate descriptions in Appendix E (Table 2). Thus, spotted owl habitat may be described as multi-aged, multi-layered forest stands (Fig. 34), with sufficient tree density and basal area (Fig.

35) to provide a significant total canopy closure (>90 percent) and a cool microclimate. Suitable foraging and nesting habitat would be provided as a result.

b. Variations in habitat characteristics, however, are desirable. Subtle changes in stand structure and physiography, which resulted in significant distinctions in habitat selection by the sexes and between habitat areas would be accommodated as a result.

1). A mosaic of stands approximating foraging habitats (core habitat descriptions: Tables 3, 7, and 11 in Appendix E) and roosting habitats (roost habitat descriptions: Tables 2, 6, and 10 in Appendix E) should occur within each "territory". I considered these to be more "desirable" habitats.

2). Forest stands which approximate non-core habitat descriptions (Tables 4, 8, and 12 in Appendix E) should be enhanced where possible and needed to meet roosting and core area habitat characteristics. Non-core habitats would represent the least desirable habitat situation.

3). Optimum stand cover (stem density and basal area, canopy closure, etc.) should

be maintained or enhanced within 182 m (600 ft) of perennial or annual water sources; thus, providing optimum roosting and foraging habitats.

c. Rotation periods should be sufficient to sustain and perpetuate the following:

1). Multi-aged stand characteristics.

2). Multilayered canopy structures.

3). Tree species diversity.

a). Douglas-fir should predominate in the overstory (>52.5 cm (20.9 in) DBH size classes).

b). A mixture of hardwoods should predominate, in occurrence with Douglas-fir, in the understory (<52.3 cm (20.0 in) DBH size classes).

4). Roost and foraging habitat characteristics.

5). Snag density.

d. An effort should be made to maintain suitable nesting substrate; 0.8 live or snag trees/ha (2 trees/ac) (DBH: >90.0 cm; 36.0 in) which show potential nest tree characteristics (cavities, broken tops, or defects).

e. The diversity and abundance of prey may be related to the diversity or microhabitat characteristics of lower tree and shrub strata (less

than 9.1 m (30.0 ft) in height). Further, adult and recently fledged owls are typically dependent upon trees or tall shrubs in the lower strata for roosting and foraging perches and for cover. Therefore, it would be desirable to maintain or enhance the integrity or degree of ground cover for the following:

1). Dead and down woody material.
   a). Scatter slash or pile slash if cover is lacking for small mammals.
   b). Retain snags to provide replacements for dead and down logs.
2). Herbs.
3). Shrubs.
4). Trees less than 10.0 cm (4.0 in) DBH, to provide overstory and understory tree replacements. Stand maintenance may be occasionally required to control hardwood stem density or the extent of shrub cover, factors which could act to limit an owl's maneuverability through a stand and access to prey on the ground, respectively. Hardwood stems and shrub cover, however, should not be eliminated.

Stand size.

a. Mature/old-growth tree stands within each "territory" should be large (>120 ha; 300 ac), continuous, and occur in one to two parcels. Stands less than 120 ha in size may be of limited value for management purposes.

Stand arrangement.

a. Mature/old-growth tree stands should be connected by corridors of suitable habitat. Corridor characteristics have been previously discussed.

b. Riparian areas and inner-gorge areas should be included in combination with other suitable habitat types to meet all of the spotted owl's habitat needs, both for the SOMA's, overall, and for individual "territories".

1. Continue to investigate and refine knowledge of the spotted owl's habitat requirements (e.g., dependence on stand age characteristics), population dynamics (survival, productivity, etc.) and biology (dispersal, interchange between geographical areas, etc.).

2. Refine knowledge of the spotted owl's prey base habitat requirements, population dynamics, and biology.

3. Monitor the effects of habitat modification upon factors contributing to the maintenance of viable spotted owl population, including survival, productivity, dispersal, and tenacity to historical use areas.

4. Evaluate potential of artificial nesting structures. Artificial nesting structures have been successfully used as tools for studying the life histories or populations, management, or providing nesting habitat for some large owl species, including tawny owls (Southern 1970), great horned owls (Dunstan and Harrell 1973), and great gray owls, Strix nebulosa, (Hoglund and Lansgren 1968). Sisco (1980, unpublished) initiated a pilot project on the Lower Trinity Ranger District, Six Rivers National Forest, to determine if radio-tagged spotted owls used nest boxes placed near or within their

activity areas. Sisco, (pers. comm.) has not observed spotted owls to use any of these boxes, to date. However, the results may be enhanced by altering the design, placement, and availability of nest boxes. Marcot (1978) discussed the characteristics, design, and placement of different nest boxes for spotted owls. Oleńdorff et al. (1980) reviewed techniques of raptor management.

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TABLES

Table 1. A Comparison of Habitat Information from the Six Rivers National Forest Wildland and Resource Information System (WRIS) Timber Stand Classification System and the California/Wildlife Habitat Relationships (WHR) Program (North Coast/Cascade Zone) (Marcot 1979) Used to Construct Habitat Type (HT) Codes. HT codes give , seral stage, canopy closure, and hardwood component information for both overstory and understory. Six-digit HT codes were constructed by interpreting WRIS timber stand map information, and then choosing the appropriate alpha/numerical code appearing under the asterisk, left to right across the table.

Overstory Size Class		Overstory Canopy Closure		Overstory Hardwood		Understory Size Class		Understory Canopy Closure		Understory Hardwood	
* WRIS	* WHR	WRIS	* WHR	*		WRIS	* WHR	WRIS	* WHR	*	
	1 Grass/ Forb	-,=	A 0-40%	1	Oregon Oak Black Oak Conifer		1 Grass/ Forb	-,=	A 0-40%	1	Conifer
1	2 Brush/ Sapling	=	B 40-70%	2	Oregon Oak Black Oak	1	2 Brush/ Sapling	=	B 40-70%	2	Oregon Oak Black Oak Conifer
2,3	3 Pole/ Medium Tree	=	C 70% +	3	Tanoak Madrone/ Conifer	2,3	3 Pole/ Medium Tree	=	C 70% +	3	Oregon Oak Black Oak
4,5	4 Mature/ Old-growth Tree			4	Tanoak Madrone	4,5	4 Mature/ Old-growth Tree			4	Tanoak Madrone/ Conifer
										5	Tanoak Madrone
				0	Conifer		0 None		0 None	Z	None
*WHT code sequence: First digit		Second digit		Third digit		Fourth digit		Fifth digit		Sixth digit	

An example of WRIS/WHR interface:

WRIS timber stand label DTOM3-/D1-

WHT code label 3A32A1

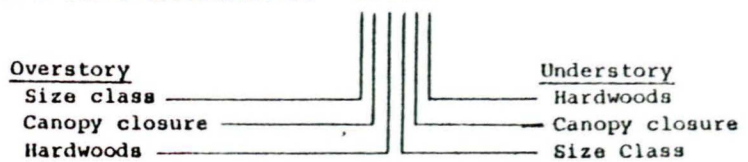


Table 2. Code Names, Observation Periods, and Study Areas for 12 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981.

Owl Code Name	Observation Period	No. Days In Observation Period	Study[1] Area
Uno [2,5,7,11]	9 July-25 Aug 1980	58	A
Nieve [2,6,12]	16-25 Sept 1980	10	A
Despacio [2,4,5,7,11]	16-17 Sept 1980	2	A
Pancho [2,3,5,8,11]	12 Aug-21 Aug 1980	10	B
	23 Sept-23 Oct 1980	32	
	8 Feb-24 Aug 1981	199	
Lucia [2,3,5,8,12]	19 Aug-24 Sept 1980	37	B
	17 Mar-9 Aug 1981	146	
Harvey [3,5,9,11]	11 Mar-12 Aug 1981	155	C
Billy Bob [3,4,5,9,12]	2 Apr-6 July 1981	96	C
Bubba [3,5,7,11]	29 Apr-20 June 1981	53	C
Suave [3,6,7,12]	5 May-13 Aug 1981	101	C
Chopo [3,6,7,11]	5 May-4 July 1981	61	C
Mayo [3,5,10,11]	12 May-17 Aug 1981	98	C
Catalina [3,5,10,12]	11 May-14 Aug 1981	96	C

1 Study Areas: A= Leary Creek, B= Fourmile Creek, and C= Mosquito Creek
2 Observed during pilot study
3 Observed during final study
4 Observed but not radio-tagged
5 Adult
6 Immature
7 Unpaired
8 Paired, nesting attempt unknown
9 Paired, one young produced in 1981
10 Paired, unsuccessful nesting attempt in 1981
11 Male
12 Female

Table 3. Distribution of Radio-Telemetry Locations by Activity Type for 12 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981 (after Forsman 1980).

	Activity Type						
	Roosting	Foraging	Moving	Calling	Interacting	On Nest	Total
Uno [1,3]		14	18				32
Pancho [1,3]		43	76	20			139
Lucia [1,3]		34	124	10			168
Nieve [1,3]		4	10				14
Despacio [1,3]		2	4				6
Harvey [1,3]		80	116	1	17	3	4	221
Billy Bob [1,4]		12			1		3	16
Bubba [1,3]		30	43	2	3	1		79
Suave [2,4]		55	124	10	4	7		200
Chopo [2,3]		14	49	15	2	1		81
Mayo [1,3]		52	144	8	11	3	2	220
Catalina [2,4]		49	127	13	3		3	195
Total		389	835	79	41	15	12	1371

1 Adult Owl
2 Immature Owl
3 Male Owl
4 Female Owl

Table 4. Size and Composition of Home Range Areas Occupied by Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981, Indicating the Percentage of the Total Home Range Area Occupied by each Seral Stage. Data primarily represent observations made during the breeding season (1 Feb.-1 Oct.).[1]

	Seral Stage [2]						Total Home Range Area by Minimum Polygon Method ha (ac)
	2		3		4		
	ha (ac)	%	ha (ac)	%	ha (ac)	%	
Individual home ranges:							
Uno [3,5]	115.2 (288)	16.9	169.6 (424)	24.9	396.0 (990)	58.2	680.8 (1702)
Pancho [3,5]	77.2 (193)	28.4	78.0 (195)	28.6	117.2 (293)	43.0	272.4 (681)
Lucia [3,6]	62.8 (157)	16.3	237.2 (593)	61.8	84.0 (210)	21.9	384.0 (960)
Harvey [3,5]	75.2 (188)	39.6	21.2 (53)	11.1	93.6 (234)	29.7	190.0 (475)
Bubba [3,5]	40.8 (102)	17.0	61.2 (153)	25.5	138.0 (345)	51.5	240.0 (600)
Suave [4,6]	226.0 (565)	40.3	112.0 (280)	20.0	222.4 (556)	39.7	560.4 (1401)
Mayo [3,5]	71.2 (178)	23.3	77.6 (194)	25.4	156.8 (392)	51.3	305.6 (764)
Catalina [3,6]	158.8 (397)	23.7	162.0 (405)	24.2	349.2 (873)	52.1	670.0 (1675)
Mean:	103.4 (258.5)	25.7	114.8 (287.1)	25.4	194.6 (486.6)	43.4	

	Mean home range-ha (ac)	n	Range-ha (ac)
All owls combined:			
Total	412.8 (1032)	8	190.0-680.8 (475-1702)
Male	337.6 (844)	5	190.0-680.8 (475-1702)
Female	538.0 (1345)	3	384.0-670.0 (960-1675)
Adults:			
Total	367.2 (918)	7	190.0-680.8 (475-1702)
Male	337.6 (844)	5	190.0-680.8 (475-1702)
Female	527.2 (1318)	2	384.0-670.0 (960-1675)

Table 4 (continued).

	Seral Stage[2] 2 ha (ac) %	3 ha (ac) %	4 ha (ac) %	Total Home Range Area by Minimum Polygon Method ha (ac)
Collective home ranges of pairs:				
Fourmile Creek	88.8 (222) 17.6	267.6 (669) 53.2	146.8 (367) 29.2	503.2 (1258)
Bee Tree Creek	166.0 (415) 19.5	191.2 (478) 22.5	493.2 (1233) 58.0	850.4 (2126)
mean:	127.4 (318.5) 18.6	229.4 (573.5) 37.9	320.0 (800.0) 43.6	676.8 (1692)
Mosquito Creek collective home range:	454.4 (1136) 29.5	409.2 (1023) 26.5	679.2 (1698) 44.0	1542.8 (3857)

1 Does not include extensive acreage used by a dispersing immature male (Chopo), which would have exaggerated home range results.
2 Seral stages: 2 (brush/seedling/sapling tree stand); 3 (pole/medium tree stands); and 4 (mature/old-growth tree stand) (Marcot 1979).
3 Adult owl.
4 Immature owl.
5 Male owl.
6 Female owl.

Table 5: A Summary of Habitat Selection by 7 Northern Spotted Owls (6 Adult and 1 Immature) on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981.[a]

Habitat type[b]	Proportion of locations occurring in habitat type	Proportion of home range area occupied by habitat type	No. of owls using habitat type in proportion to its occurence within home range area		
			signif. less than expected (p<.05)	Not signif. different than expected	Signif. greater than expected (p<.05)
Seral stage 4 (mature/old-growth tree stand)	.712 - 1.000	.176 - .815	--	--	7
Seral stage 3 (pole/medium tree stand)	.000 - .288	.185 - .824	7	--	--
Seral stage 2 (brush/seedling/ sapling tree stand)	.000 - .110	.163 - .403	c	--	--

a Foraging (n=378) and roosting (n=238) data were pooled for each owl because heterogeneity chi-square analyses indicated that the distribution of each owls foraging and roosting locations were the same for each habitat type (P>.05).

b Seral stages follow Marcot (1979).

c I concluded that all seven owls did not prefer seral stage 2 for foraging or roosting because only 2.3% (n=9) of all foraging locations and no roosts occurred within this habitat type. The inclusion of this habitat type in the analysis would have violated assumptions associated with chi-square and habitat selection analyses (Cochran 1954; Neu et al. 1974; Zar 1974).

Table 6. Characteristics of Habitat Type Codes Used by 8 Northern Spotted Owls for Foraging or Roosting on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981.

Habitat type code[1]	Propor. of total home range area	Total area within home range boundaries ha(ac) n	$\bar{x}$	±S.E.	range
4A02A1	0 - .186	1	127 (317)	--	--
4A02A3	0 - .015	1	10 (25)	--	--
4A03A1	.054 - .485	6	154 (386)	116 (290)	27-731 (67-1827)
4A03B1	.003 - .040	2	8 (19)	--	--
4A03B4	.109 - .173	3	152 (381)	14 (34)	33-78 (83-194)
4B02B4	0 - .025	1	14 (36)	--	--
4B03B4	.013 - .355	7	57 (142)	9 (22)	190-97 (76-242)
4B03C4	0 - .024	4	17 (42)	2 (4)	14-22 (34-54)
4B02A5	.050 - .065	1	4 (9)	--	--
3A02A1	.101 - .145	3	52 (129)	13 (31)	39-77 (97-193)
3A02A3	.051 - .067	2	18 (44)	8 (20)	10-26 (24-64)
3A02B4	0 - .042	1	24 (59)	--	--
3A03A3	0 - .076	1	23 (58)	--	--
3A03B1	0 - .013	1	4 (10)	--	--

Table 6 (continued).

Habitat type code[1]	Propor. of total home range area	Total area within home range boundaries ha(ac)			
		n	$\bar{x}$	±S.E.	range
3A03B2	.006	1	14 (36)	--	--
3A03C2	.038	1	26 (64)	--	--
3B000Z	.089	5	17 (42)		.8-36 (2-89)
3B03C2	.008	1	5 (13)	--	--
3B300Z	.070	1	48 (120)	--	--
3B41B1	.005	1	3 (8)	--	--
3C100Z	.013	1	4 (10)	--	--

1/ Habitat type codes give seral stage, canopy closure, and hardwood component information, both for the overstory and understory. Seral stages are: seral stage 2 = brush/seedling/sapling tree stage; seral stage 3 = pole/medium tree stage; seral stage 4 = mature/old-growth tree stage (Marcot 1979). Canopy closures are: A = 0-40%; B = 40-70%; C = greater than 70% (Marcot 1979). Hardwood components are: 1 = only conifers; 2 = Oregon white oak, Quercus garryana, California black oak, Quercus kelloggii, and conifers; 3 = Oregon white oak and California black oak; 4 = tanoak, Lithocarpus densiflorus, and Pacific madrone, Arbutus menziesii, and conifers; 5 = tanoak and madrone; O and Z = none.

For example:

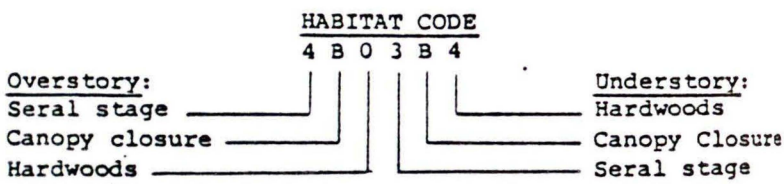


Table 7. Roost Site Characteristics for 12 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981.

Variable	n	$\bar{x}$	±S.E.	Range	% Freq. Occur.
OWL					
Height above ground - m (ft)	93	7.6 (25.0)	.5 (1.7)	0.3-24.5 (1-81)	--
Distance to trunk - m (ft)	93	1.2 (4.0)	.1 (.4)	0.3-5.2 (1-17)	--
Distance to canopy edge - m (ft)	93	2.5 (8.1)	.1 (.4)	0.3-7.6 (1-25)	--
Overhead closure n=93					
open (<10% cover)	5	-	-	-	5.4
sparse (10-40% cover)	11	-	-	-	11.8
moderate (40-70% cover)	34	-	-	-	36.6
dense (>70% cover)	43	-	-	-	46.2
Side Closure n=93					
open (<10% cover)	5	-	-	-	5.4
sparse (10-40% cover)	14	-	-	-	15.1
moderate (40-70% cover)	36	-	-	-	38.7
dense (>70% cover)	38	-	-	-	40.9
ROOST TREE					
Species	98				
madrone	6	-	-	-	6.1
tanoak	54	-	-	-	55.1
Douglas-fir	16	-	-	-	16.3
canyon-live oak	15	-	-	-	15.3
California black oak	2	-	-	-	2.0
Pacific dogwood	2	-	-	-	2.0
big-leaf maple	3	-	-	-	3.1

Table 7 (continued).

Variable	n	$\bar{x}$	±S.E.	Range	% Freq. Occur.
DBH - cm (in)	98				
all species combined	98	46.0 (18.4)	4.5 (1.8)	5-238 (2-92)	--
madrone	6	41.8 (16.7)	4.3 (1.7)	25-60 (10-24)	-- --
tanoak	54	35.0 (14.9)	17.8 (7.1)	5-165 (2-66)	--
Douglas-fir	16	87.0 (34.8)	9.8 (3.9)	10-238 (4-92)	--
canyon-live oak	15	40.3 (16.1)	9.8 (3.9)	10-150 (4-60)	--
California black oak	2	63.8 (25.5)	43.5 (17.4)	20-108 (8-43)	--
Pacific dogwood	2	11.3 (4.5)	3.8 (1.5)	8-16 (3-6)	--
big-leaf maple	3	32.5 (13)	1.5 (.6)	30-35 (12-14)	--
Height - m (ft)	98				
all species combined	98	16.5 (54.6)	1.5 (4.8)	2.7-62.1 (9-205)	--
madrone	6	15.8 (52.1)	3.5 (11.7)	8-30 (25-100)	--
tanoak	52	11.8 (38.9)	.8 (2.8)	3-35 (9-114)	--
Douglas-fir	16	40.5 (133.5)	4.9 (16.3)	9-62 (28-205)	--
canyon-live oak	15	9.2 (30.2)	1.0 (3.4)	4-18 (14-58)	--
California black oak	2	15.9 (52.5)	5.3 (17.5)	11-21 (35-70)	--
Pacific dogwood	2	8.0 (26.5)	4.4 (14.5)	4-12 (12-41)	--

Table 7 (continued).

Variable	n	$\bar{x}$	±S.E.	Range	% Freq. Occur.
big-leaf maple	3	15.9 (52.7)	4.2 (13.7)	8-22 (27-74)	--
SITE VARIABLES					
Total canopy closure (%)	112	86.7	.7	64.0-98.0	--
Overstory height - m (ft)	111	45.3 (149.4)	1.0 (3.4)	21-68 (70-225)	--
Understory height - m(ft)	111	16.1 (53.2)	.4 (1.4)	5-27 (15-90)	--
Percent slope	113	50.9	19.1	0-98	--
Aspect:					
north (338-67°)	105	-	-	-	27.0
east (68-157°)	119	-	-	-	30.6
south (158-247°)	115	-	-	-	29.6
west (248-337°)	50	-	-	-	12.9
Relationship to slope	389				
upper third	47	-	-	-	12.1
middle third	160	-	-	-	41.1
lower third	182	-	-	-	46.8
Distance to water - m (ft)	389	142.1 (468.7)	5.9 (19.6)	0.3-636 (1-2100)	--
ENVIRONMENT					
Temperature at roost - °C (°F)	110	17.6 (63.7)	-17.2 (1.0)	-0.5-30.0 (31-86)	--
Ambient temperature - °C (°F)	110	22.4 (71.8)	-17.3 (.7)	0.0-34.4 (32-100)	--

Table 8. Eigenvalues, Percentage of Variance Extracted by Each Factor, Cumulative Percentage of Variance Exteracted, and Correlation of Nine Factors with Roost Site Variables (Factor Structure Matrix).

Characteristic	Factor								
	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9
Eigenvalue	4.1	2.4	2.6	1.8	1.7	1.6	1.3	1.1	1.1
Percentage of variance extracted by factor	15.9	11.4	10.0	7.2	6.8	6.5	5.1	4.5	4.2
Cumulative percent-	15.9	27.3	37.3	44.5	51.3	57.8	63.0	67.5	71.7
Variable acronym[1]	Factor Structure Matrix (correlations less than +.30 suppressed)								
HTABGND	-.85								
DISTRNK				+.31			+.33	-.53	
DISEDGE	-.58						-.30		
OSPARSE		-.69							
ODENSE		+.71							
SSPARSE	-.39	-.70							
SDENSE		+.74							
MAD								-.89	
TOAK	+.47				+.68				
DF	-.82								
CLO					-.86				
CBO						-.79			
PD									-.83
RTDBH	-.66								
RTHT	-.92								
CCLOS							+.79		
OVSTYHT	-.37		-.51		+.39				
USTYHT					+.52	-.52			
PSLOPE		-.32		+.43					-.47
N			+.73	-.30					
E			-.92						
S				+.42		-.59			
LOWTHD				+.62			-.34		
DISWTR				-.78					
CLEAR						+.43	+.41		
TROOST	+.42	+.42	+.30						

1/ Variables Are:

HTABGND = owl height above ground
DISTRNK = owl distance to trunk
DISEDGE = owl distance to edge
OSPARSE = sparse (10-40%) overhead closure
ODENSE = dense (>70%) overhead closure
SSPARSE = sparse (10-40%) side closure
SDENSE = dense (>70%) side closure
MAD = roost tree species is madrone
TOAK = roost tree species is tanoak
DF = roost tree species is Douglas-fir
CLO = roost tree species is canyon-live oak
CBO = roost tree species is Calif. black oak
PD = roost tree species is Pacific dogwood
RTDBH = roost tree diameter at breast height
RTHT = roost tree height
CCLOS = canopy closure
OVSTYHT = overstory height
USTYHT = understory height
PSLOPE = percent slope gradient
N = north aspect
E = east aspect
S = south aspect
LOWTHD = roost location is on lower 1/3 slope
DISWTR = distance to water from roost
CLEAR = clear sky
TROOST = temperature at roost

Table 9. Prey Species in the Diet of 9 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981.

Prey species	Total numbers n	Total numbers Percent	Total biomass g	Total biomass Percent
Mammals:				
Dusky-footed wood rat, *Neotoma fuscipes*	108	45.0	29,052	84.5
Red tree vole, *Arborimus longicaudus*	30	12.5	810	2.4
Northern flying squirel, *Glaucomys sabrinus*	17	7.1	1,955	5.7
Mouse, *Microtus* spp.	13	5.4	325	1.0
California meadow mouse, *Microtus californicus*	2	0.8	50	0.1
Mouse, *Peromyscus* spp.	10	4.2	250	0.7
Deer mouse, *Peromyscus maniculatus*	5	2.0	110	0.3
Mouse, *Clethrionomys* spp.	5	2.0	115	0.3
Western red-backed mouse, *Clethrionomys occidentalis*	5	2.0	115	0.3
Shrew, *Sorex* spp.	4	1.7	40	0.1
Harvest mouse, *Reithrodontomys* spp.	4	1.7	100	0.3
Rabbit, *Lepus* spp.	1	0.4	200	0.6
Chipmunk, *Eutamius* spp.	1	0.4	80	0.2
Chickaree, *Tamiasciurus douglasi*	1	0.4	208	0.6

Table 9 (continued).

Prey species	Total numbers n	Total numbers Percent	Total biomass g	Total biomass Percent
Other mammals				
mouse size	11	4.6	275	0.8
squirrel size	3	1.3	300	0.9
Birds:				
Small bird	4	1.7	360	1.0
Insects:				
Jerusalem cricket, *Stenopelmatus fuscus*	9	3.8	18	< 0.1
Beetle, *Cerambycidae*	4	1.7	4	< 0.1
Beetle, *Coleoptera*	3	1.3	1	< 0.1
TOTAL	240	100.0	34,368	100.0

Table 10. Distribution of Foraging and Roosting, Vegetation Plots for 10 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981.

	Forage					
	Core area[1]		Non-core area[2]		Roost[3]	
	n	%	n	%	n	%
Uno [4,6]	8	2.0	--	--	--	--
Pancho [4,6]	11	2.8	6	12.5	13	26.5
Lucia [4,7]	66	16.6	6	12.5	17	34.7
Nieve [5,7]	10	2.5	--	--	--	--
Harvey [4,6]	55	13.8	6	12.5	10	18.4
Bubba [4,6]	20	5.0	6	12.5	2	4.1
Suave [5,7]	65	16.3	6	12.5	3	6.1
Chopo [5,6]	24	6.0	6	12.5	--	--
Mayo [4,6]	73	18.4	6	12.5	2	4.1
Catalina [4,7]	66	16.6	6	12.5	3	6.1
TOTAL	398	100.0	48	100.0	50	100.0

1 Core areas for each owl were defined by timber stand polygons that accounted for greater than 55% of all foraging locations per individual owl.
2 Area exclusive of core area.
3 Verified roost locations.
4 Adult owl.
5 Immature owl.
6 Male owl.
7 Female owl.

Table 11. A Comparison of Mean Values or Frequency of Occurrence for Selected Characteristics Among Different Spotted Owl Habitat Categories.

Characteristic[1]	Habitat Category[2]											
	Sexes Combined				Male				Female			
	Roost (n=50)	Core (n=398)	Non-core (n=48)	All (n=496)	Roost (n=27)	Core (n=191)	Non-core (n=30)	All (n=248)	Roost (n=23)	Core (n=207)	Non-core (n=18)	All (n=248)
Tree Density-stems/ha(stems/ac):												
12.5-25.0 cm (5-10 in) DBH interval												
Conifer	34.0 (13.6)	74.3 (29.7)	74.5 (29.8)	70.3 (28.1)	30.5 (12.2)	76.5 (30.6)	67.5 (27.0)	70.5 (28.2)	38.0 (15.2)	72.3 (28.9)	86.0 (34.4)	70.3 (28.1)
Hardwood	209.5 (83.8)	156.5 (62.6)	132.3 (52.9)	159.5 (63.8)	193.5 (77.4)	158.3 (63.3)	149.3 (59.7)	161.0 (64.4)	228.3 (91.3)	154.5 (61.8)	104.3 (41.7)	157.8 (63.1)
Greater than 90.0 cm (36 in) DBH												
Conifer	41.0 (16.4)	29.3 (11.7)	19.3 (7.7)	29.8 (11.9)	43.5 (17.4)	22.8 (9.1)	15.8 (6.3)	24.0 (9.6)	38.0 (15.2)	35.0 (14.3)	25.0 (10.0)	35.3 (14.1)
Hardwood	-- --	1.8 (.7)	1.0 (.4)	1.5 (.6)	-- --	2.0 (.8)	.8 (.3)	1.8 (.7)	-- --	3.0 (1.2)	1.3 (.5)	1.0 (.4)
All DBH intervals combined												
Conifer	133.0 (53.2)	200.8 (80.3)	180.8 (72.3)	192.0 (76.8)	132.8 (53.1)	202.5 (81.0)	166.5 (66.6)	190.8 (76.3)	132.3 (52.9)	199.3 (79.7)	454.3 (181.7)	193.5 (77.4)
Hardwood	336.6 (134.6)	266.3 (106.5)	232.8 (93.1)	269.8 (107.9)	326.8 (130.7)	283.3 (113.3)	261.5 (104.6)	281.8 (112.7)	347.5 (139.0)	254.3 (101.7)	184.8 (73.9)	257.5 (103.0)
Tree Basal Area - m^2/ha (ft^2/ac):												
12.5-25.0 cm (5-10 in) DBH interval												
Conifer	.991 (4.406)	2.228 (9.903)	2.237 (9.940)	2.104 (9.353)	.870 (3.866)	2.312 (10.277)	1.926 (8.560)	2.108 (9.371)	1.134 (5.041)	2.151 (9.559)	2.753 (12.239)	2.100 (9.334)
Hardwood	5.744 (25.531)	4.305 (19.134)	3.575 (15.889)	4.379 (19.465)	5.664 (25.175)	4.449 (19.774)	4.101 (18.228)	4.539 (20.175)	5.833 (25.948)	4.172 (18.573)	2.698 (11.992)	4.219 (18.754)
Greater than 90.0 cm (36 in) DBH												
Conifer	48.305 (214.685)	38.255 (170.021)	20.429 (90.794)	37.542 (166.857)	49.522 (220.098)	29.669 (131.865)	16.700 (74.226)	30.262 (134.498)	46.874 (208.331)	46.176 (205.229)	26.641 (118.408)	44.823 (199.215)
Hardwood	-- --	1.531 (6.807)	.769 (3.420)	1.303 (5.7893)	-- --	1.834 (8.152)	.701 3.116)	12.497 (6.655)	-- --	1.252 (5.567)	.883 (3.927)	1.109 (4.931)

Table 11 (continued).

Characteristic[1]	Habitat Category[2]											
	Sexes Combined				Male				Female			
	Roost (n=50)	Core (n=398)	Non-core (n=48)	All (n=496)	Roost (n=27)	Core (n=191)	Non-core (n=30)	All (n=248)	Roost (n=23)	Core (n=207)	Non-core (n=18)	All (n=248)
All DBH intervals combined												
Conifer	62.812 (279.166)	56.830 (252.579)	37.037 (164.611)	55.518 (246.747)	64.822 (288.099)	45.594 (220.420)	32.218 (143.194)	49.150 (218.445)	60.453 (268.682)	63.507 (282.256)	45.068 (200.305)	61.885 (275.048)
Hardwood	15.152 (67.342)	14.979 (66.576)	13.917 (61.855)	14.894 (66.197)	17.023 (75.660)	16.737 (74.391)	14.968 (66.525)	16.554 (73.577)	12.954 (57.575)	13.357 (59.367)	12.166 (54.072)	13.233 (58.815)
Canopy closure (%):	92.8	87.8	72.8	86.9	92.5	87.0	75.0	86.2	93.2	88.5	69.1	87.6
Decadence (% Freq. Occur.):												
Low	16.0	26.4	41.7	26.8	11.1	36.6	40.0	34.3	21.7	16.9	44.4	19.4
Moderate	26.0	25.1	20.8	24.8	33.3	24.6	20.0	25.0	17.4	25.6	22.2	24.6
High	58.0	48.5	37.5	48.4	55.6	38.7	40.0	40.7	60.9	57.5	33.3	56.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ground cover (%):												
Tree (<10cm (10in) DBH)	40.8	34.9	30.2	35.1	37.6	32.1	34.1	32.9	44.5	37.5	23.7	37.1
Shrub	9.3	7.3	13.2	8.1	12.0	8.1	15.0	9.4	6.2	6.6	10.2	6.8
Herb	4.9	7.5	12.4	7.7	4.7	9.2	9.9	8.8	5.0	6.0	16.6	6.7
Litter	92.4	91.6	93.8	92.0	94.3	92.7	94.3	93.0	90.4	90.8	93.1	10.9
Logs												
diameter = 2.5-30.4 cm (1-12 in)	7.1	6.2	4.5	6.1	4.5	5.2	3.5	4.9	10.1	7.1	6.4	7.3
diameter >30.4 (>12 in)	2.6	1.9	3.0	2.1	2.8	1.9	3.5	2.2	2.4	1.9	2.2	2.0
Aspect (% Freq. Occur.):												
North	56.0	50.8	31.3	49.4	63.0	49.2	33.3	48.8	47.8	52.2	27.8	50.0
East	10.0	30.7	35.4	29.0	3.7	34.0	36.7	31.0	17.4	27.5	33.3	27.0
South	26.0	9.3	25.0	12.5	22.2	6.3	23.3	10.1	30.4	12.1	27.8	14.9
West	8.0	9.3	8.3	9.1	11.1	10.5	6.7	10.1	4.3	8.2	11.1	8.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 11 (continued).

Characteristic[1]	Habitat Category[2]											
	Sexes Combined				Male				Female			
	Roost (n=50)	Core (n=398)	Non-core (n=48)	All (n=496)	Roost (n=27)	Core (n=191)	Non-core (n=30)	All (n=248)	Roost (n=23)	Core (n=207)	Non-core (n=18)	All (n=248)
Elevation - m (ft):	857.4 (2829.3)	981.6 (3239.4)	908.1 (2996.7)	962.0 (3174.6)	879.7 (2902.9)	1008.1 (3326.7)	929.6 (3067.7)	984.6 (3249.2)	831.2 (2742.8)	957.2 3158.9)	872.2 (2878.3)	939.4 (3099.9)

1/ Tree categories are: Conifer = live conifer trees; hardwood = live hardwood trees. DBH = diameter at breast height. Decadence levels are: low = trees dead <1-year; moderate = trees dead 1- to 5-years; high = trees dead >5-years.

2/ Habitat categories are: Roost = verified roost locations; core = core area, an aggregation of timber stand polygons which accounted for greater than 55 percent of an owl's total number of foraging locations; non-core = non-core area, area exclusive of core area.

Table 12. Summary of Univariate Analysis of Variance (ANOVA), Including Multiple Comparisons Among Mean Values (Least Significant Difference Procedure) and Source of Variation from Two Way ANOVA. * = P≤ .05, ** = P≤ .01, *** = P≤ .001.

Variable	ANOVA F	ANOVA df	ANOVA P	Multiple Comparison of means results	Multiple Comparison P	Source of Variation: Sex F	Sex df	Sex P	Habitat Area F	Habitat Area df	Habitat Area P	Interaction F	Interaction df	Interaction P
10.0-12.3 cm DBH interval:														
conifer basal area	2.692	495	*	1<6	*							3.0862	2	*
27.5-52.3 cm DBH interval:														
density of live trees	2.315	495	*	4<5	*	14.784	1	*						
total tree density	2.791	495	*	1<5	*	6.444	1	*	3.411	2	*			
total basal area	2.756	495	*	1<5	*	9.212	1	*						
hardwood tree height	5.660	495	***	6,5,1,4<3	*									
52.5-89.8 DBH interval:														
conifer tree height	2.427	495	*	2<3	*									
Greater than 90.0 cm DBH interval:														
live tree density	5.229	495	***	6,5<4; 6<4	*;**	12.393	1	***	4.774	2	**			
live tree basal area	5.226	495	***	6<1,2,4; 6<4	*;**	13.122	1	***	24.770	2	***			
conifer tree density	6.103	495	***	6,5<2,1,4; 6<4	*;**	14.777	1	***	5.548	2	**			
conifer tree basal area	5.394	495	***	6<2,1,4; 6<4	*;**	13.405	1	***	4.961	2	**			
total tree density	4.568	495	***	6,5<4; 6<4	*;**	9.014	1	**	4.794	2	**			
total tree basal area	4.563	495	***	6<1,2,4; 6<4	*;**	9.420	1	**	4.914	2	**			
All DBH intervals combined:														
total live tree basal area	4.062	495	**	6<5,1,2,4; 6<4	*;**	5.845	1	*	5.622	2	**			
total conifer basal area	4.311	495	***	6<5,1,2,4; 6<4	*;**	9.251	1	*	4.528	2	*			
total basal area	3.375	495	**	6,3,5<4; 6<4	*;**				5.642	2	*			
Canopy closure:	7.819	495	***	3,6<5,2,4,1; 3,6<5,2,4,1	*				8.251	2	***			
Ground cover:														
herb	2.866	495	*	4,1,2,5<3; 4<3	*;**				3.403	2	*			
shrub	2.656	495	*	1,2,5<6	*				3.664	2	*			
small logs (diameter = 2.5-30.0 cm)	2.655	495	*	6,4,5<1; 6<1	*;**	9.071	1	**						
Elevation:	7.731	495	***	1,3,4<2<5; 1<5	*;**	10.718	1	***	15.104	2	**			
Aspect:														
South	2.736	495	***	4<2,3,5,6; 4<6	**				5.223	2	**			

1/ Codes are: 1 = female roost habitat area (n=23); 2 = female core habitat area (n=207); 3 = female non-core habitat area (n=18); 4 = male roost habitat (n=27); 5 = male core habitat area (n=191); and 6 = female non-core habitat area (n=30).

Habitat areas are: roost = verified roost location; core = an aggregation of timber stand polygons which accounted for greater than 55% of any owl's total number of foraging locations; non-core area = area exclusive of core area.

FIGURES

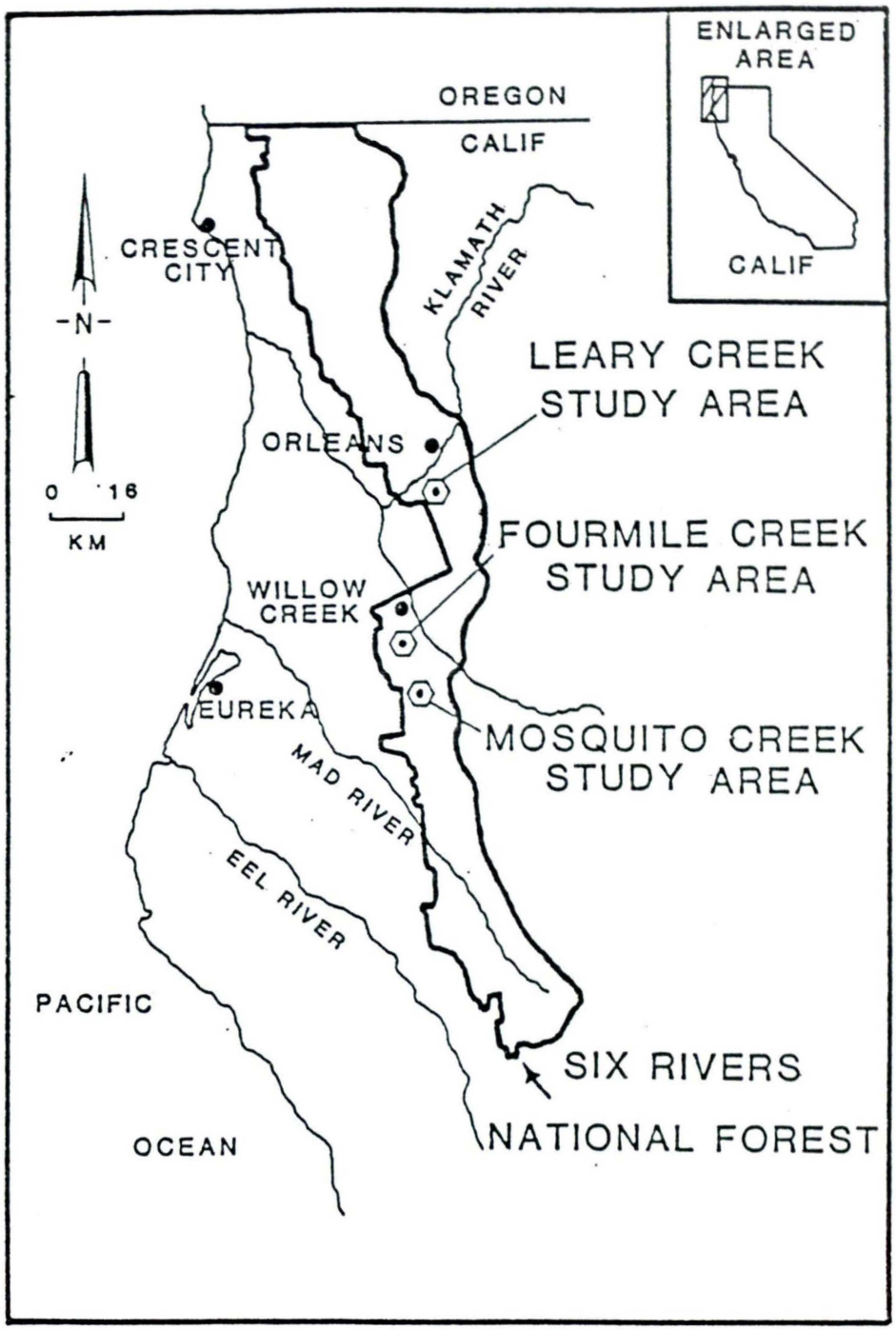


Figure 1. Distribution Of Northern Spotted Owl Radio-Telemetry Study Areas on the Six Rivers National Forest, Humboldt County, California, 9 July 1930 to 24 August 1981.

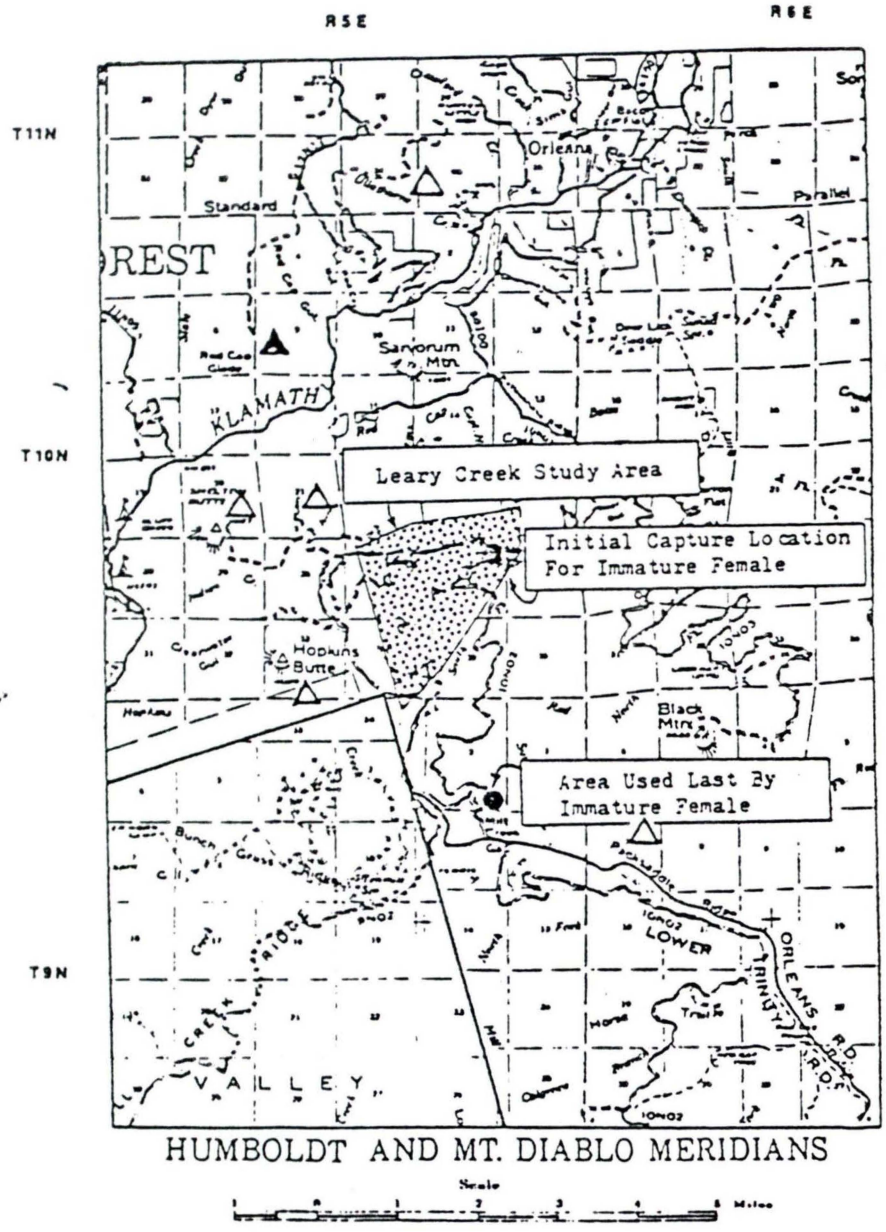


Figure 2. Northern Spotted Owl Radio-Telemetry Study Area Near Leary Creek on the Six Rivers National Forest, Humboldt County, California, 9 July to 24 August 1980. The home range area (shaded portion) of an adult male northern spotted owl (Uno) is shown with respect to historical sightings of spotted owl individuals (open triangles) or pairs (solid triangles), since 1978. All owl pairs were verified during 1980.

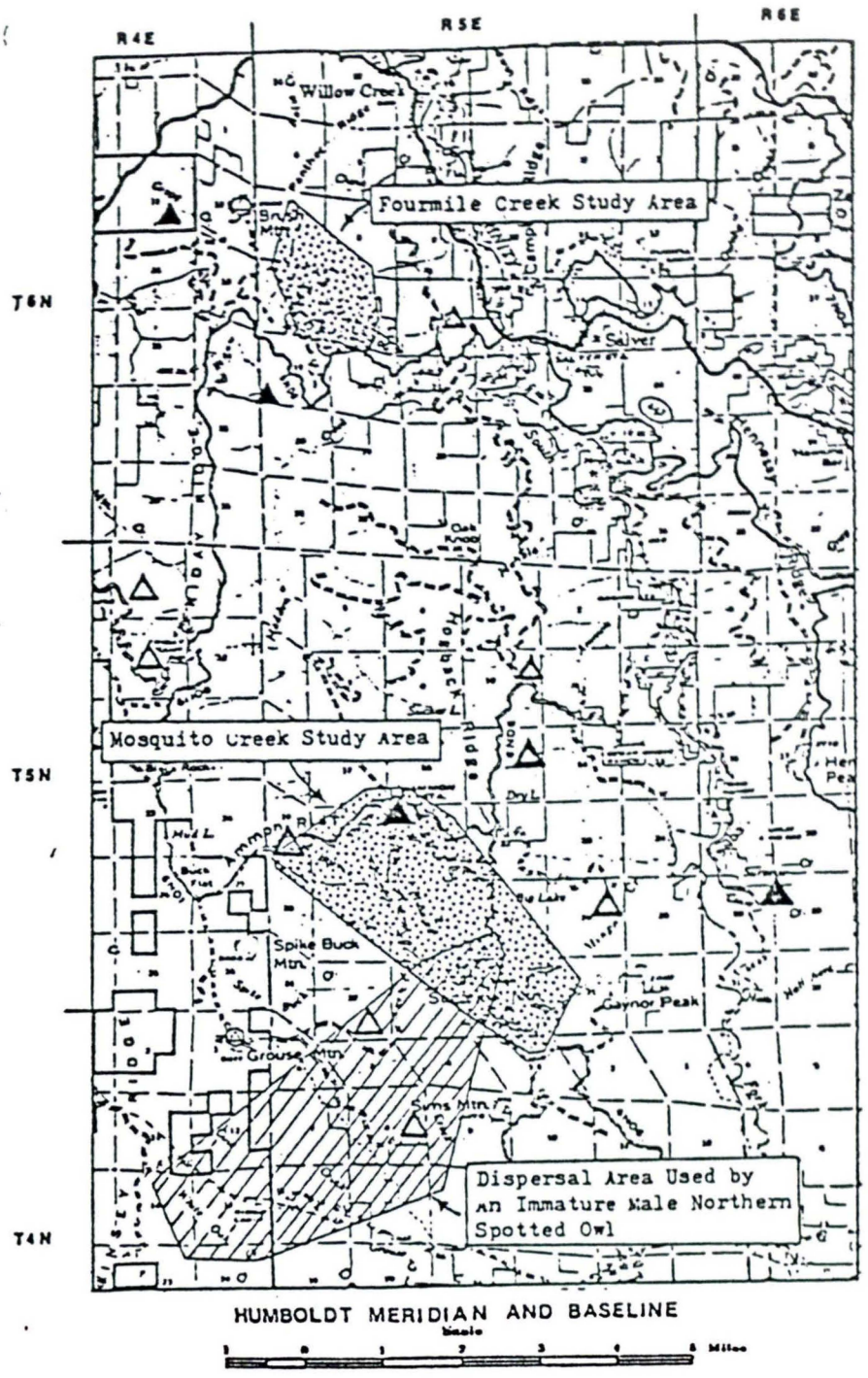


Figure 3. Northern Spotted Owl Radio-Telemetry Study Areas Near Fourmile Creek and Mosquito Creek on the Six Rivers National Forest, Humboldt County, California, 12 August 1980 to 24 August 1981, Respectively. Collective home range areas are shown with respect to historical sightings of spotted owl individuals (open triangles) or pairs (solid triangles), since 1978. All owl pairs were verified during 1980-1981. The dispersal area used by an immature male northern spotted owl (chopo) is indicated.

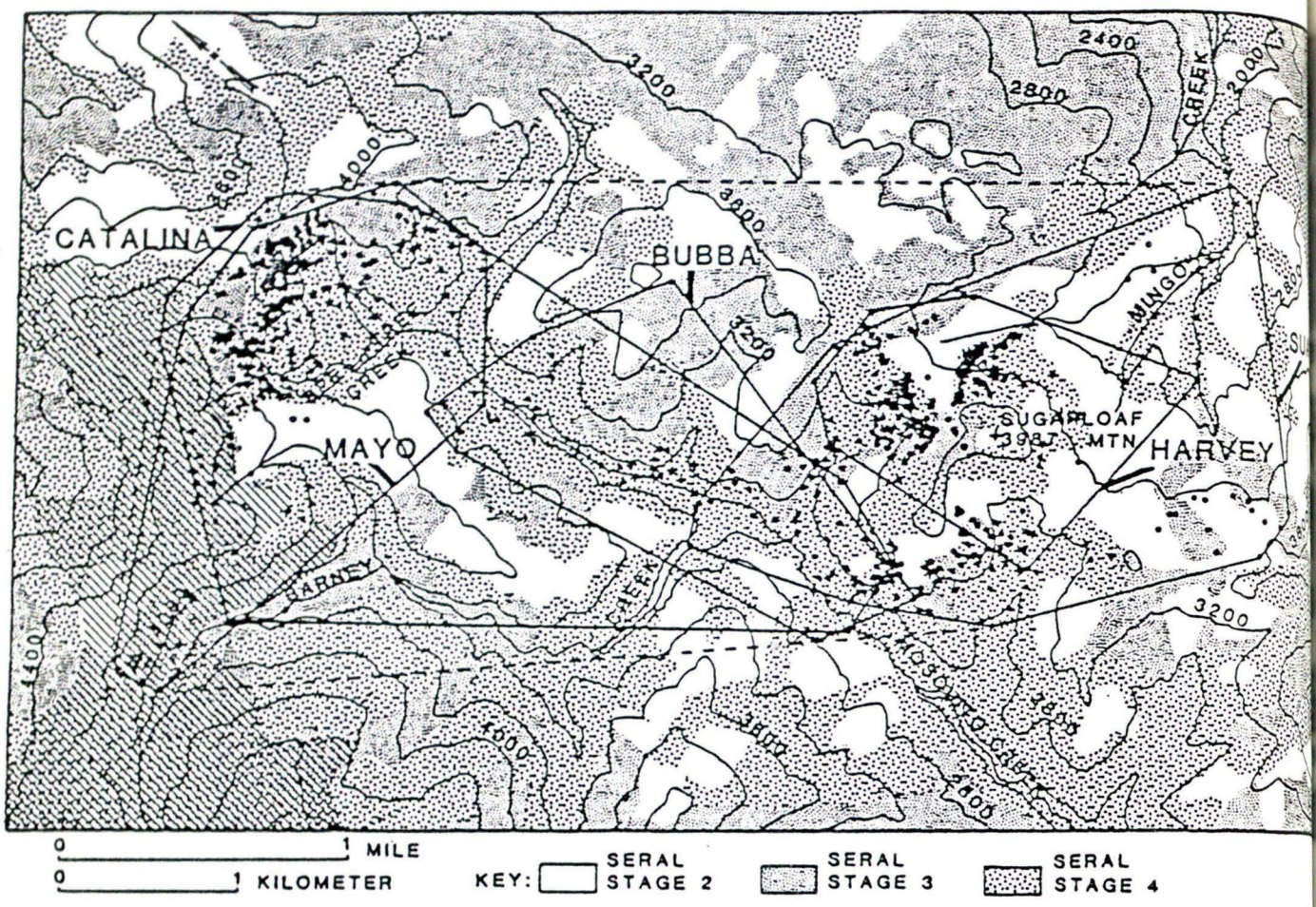


Figure 4. Location of Coast Range Montane Forest (Striped Area; Kuchler 1977) Within the Mosquito Creek Study Area on the Six Rivers National Forest, Humboldt County, all Other Areas are Representative of a Mixed Evergreen Forest (Sawyer et al. 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Telemetry locations (foraging and roosting) are shown for all radio-tagged owls within the Mosquito Creek study area, 11 March to 24 August 1981. Owls are: Catalina (female); Mayo (male); Bubba (male); Harvey (male); Suave (female) (see Tables 3-4). Nest locations (open triangles) are indicated.

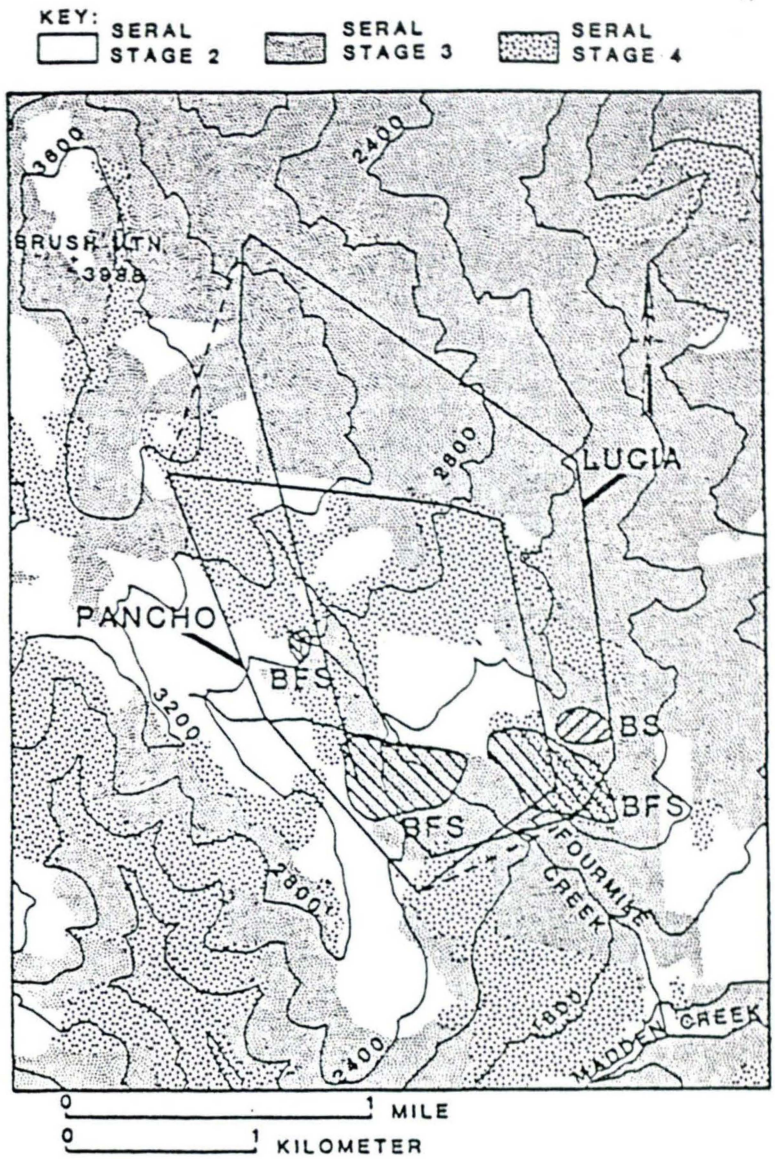


Figure 5. Locations of Brush Flood Salvage (BFS) and Bowl Salvage (BS) Sale Areas Within the Fourmile Creek Study Area. All areas are representative of a mixed evergreen forest (Sawyer et al. 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Owls are: Pancho (male); Lucia (female).

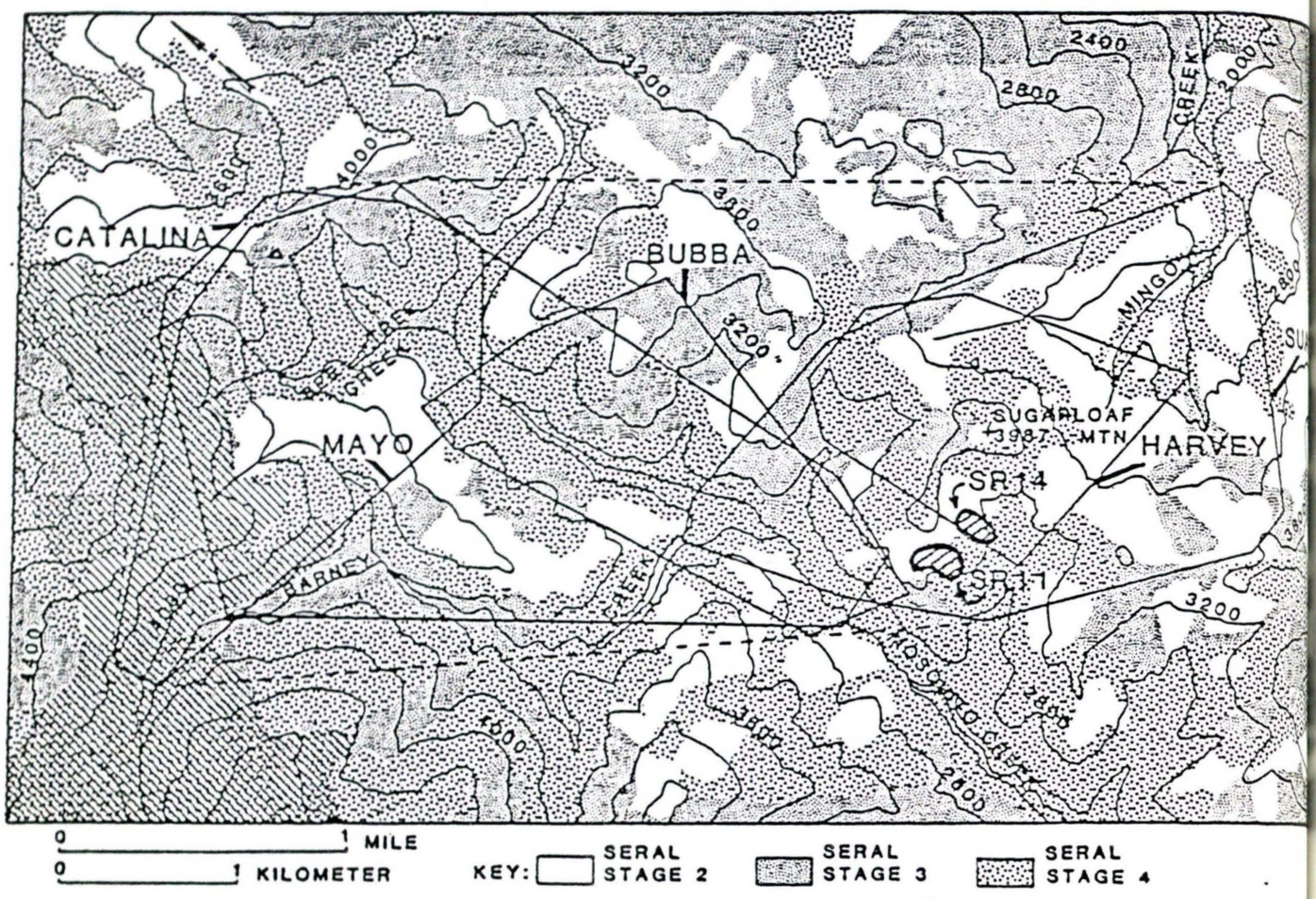


Figure 6. Locations of Sims Ranch Units 11 (SR 11) and 14 (SR 14) Within the Mosquito Creek Study Area . mixed evergreen forest (Sawyer et al. 1977) is the predominant vegetation. Coast range montane forest (Küchler 1977) is represented by the striped area in the lower, left-hand corner of the figure. Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas , respectively. Owls are: Catalina (female); Mayo (male); Bubba (male); Harvey (male); Suave (female) (see Tables 2-4). Nest locations (open triangles) are indicated.

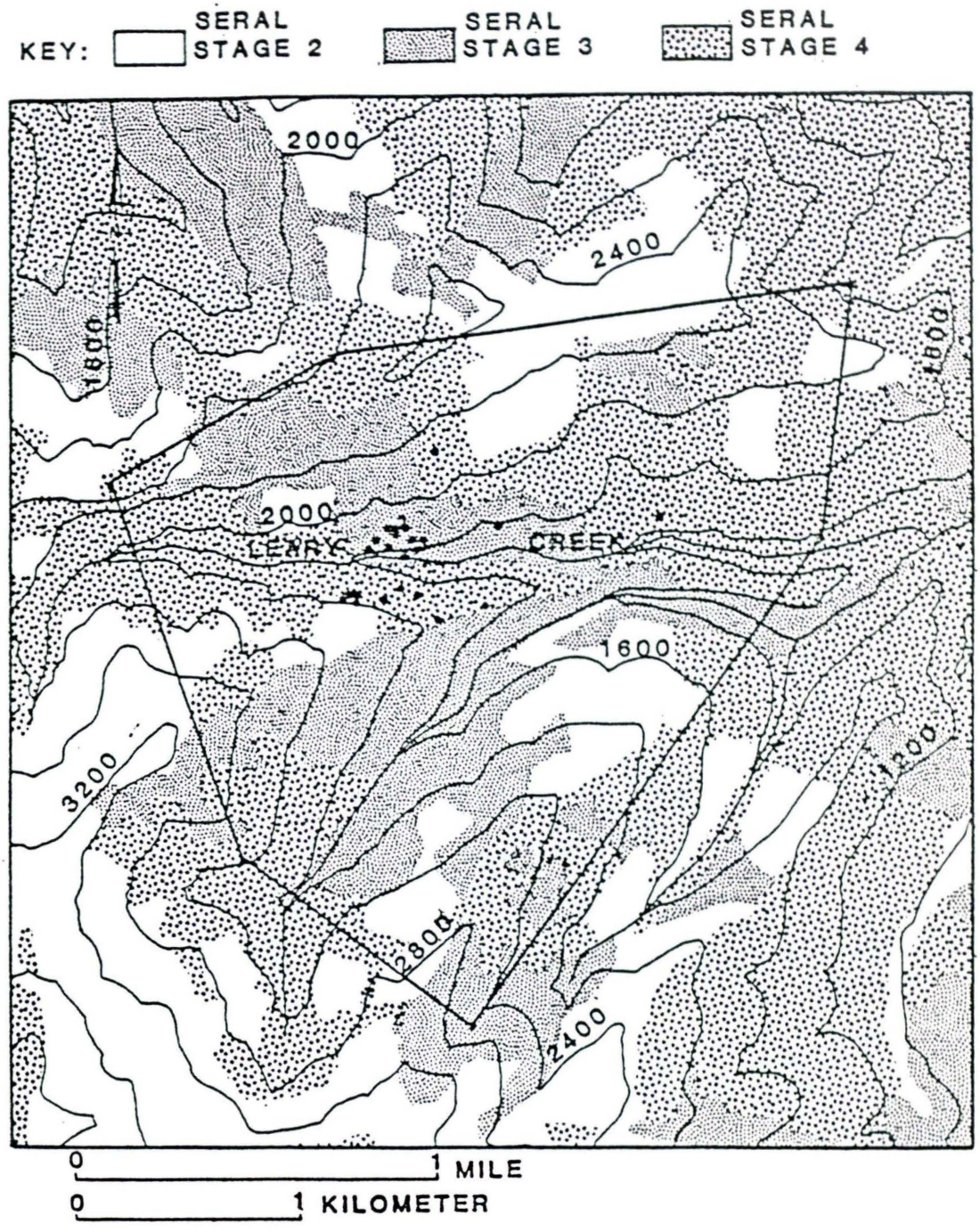


Figure 7. Radio-Telemetry Locations (Foraging and Roosting Describing the Home Range Area of an Adult Male Northern Spotted Owl (Uno) Near Leary Creek on the Six Rivers National Forest, Humboldt County, California, 9 July to 25 August 1980. All areas are representative of a mixed evergreen forest (Sawyer et al. 1977). seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet.

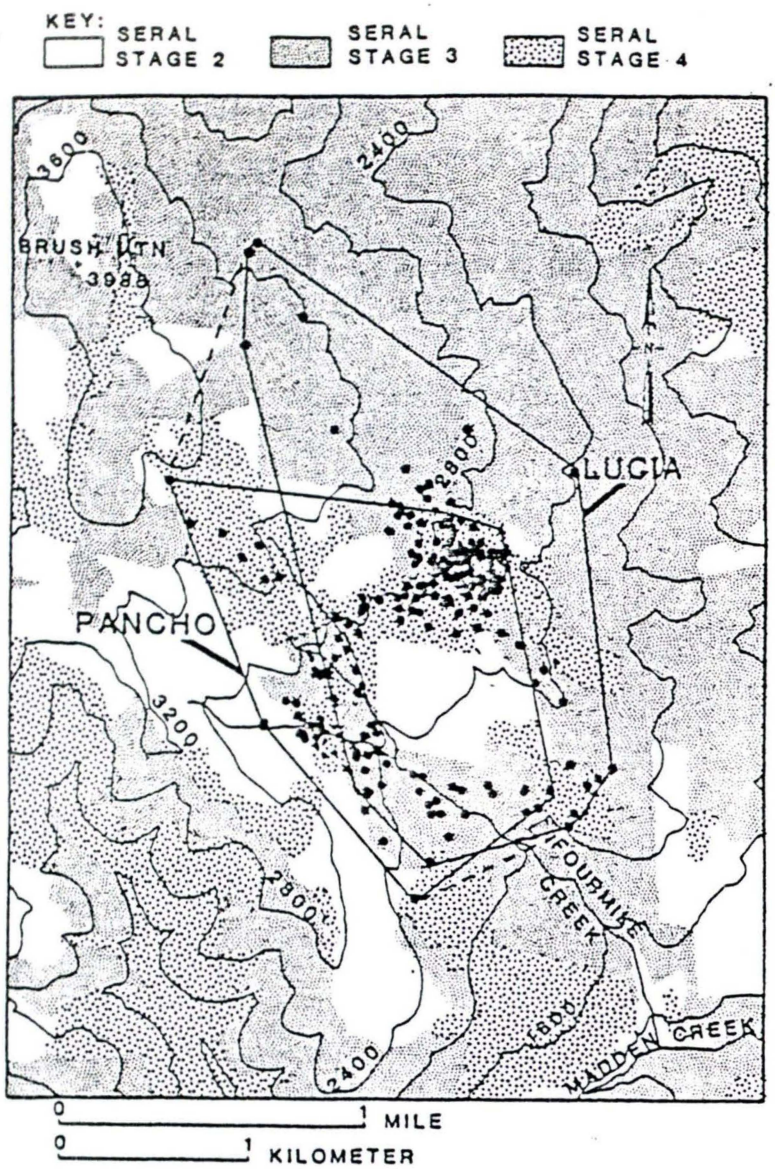


Figure 8. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Adult Northern Spotted Owl Pair (Male: Pancho; Female: Lucia) Near Fourmile Creek on the Six Rivers National Forest, Humboldt County, California, 12 August 1980 to 24 August 1981. All areas are representative of a mixed evergreen forest (Sawyer et al. 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively.

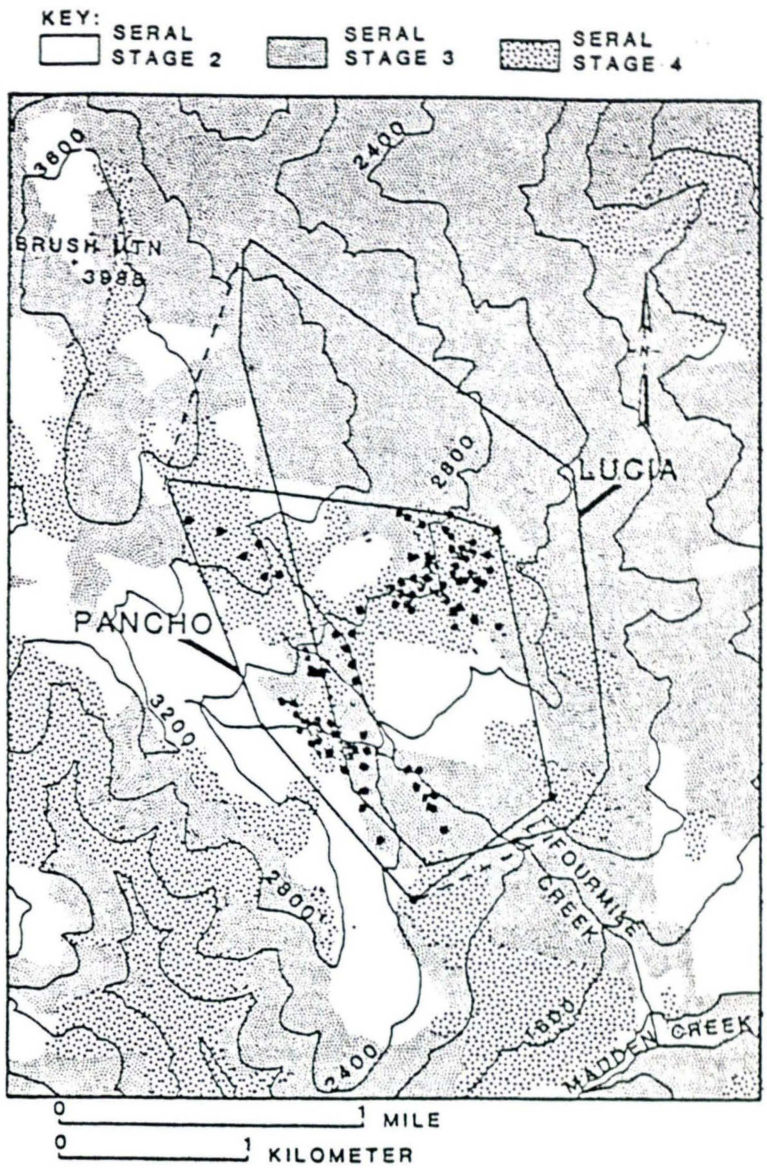


Figure 9. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Adult Male Northern Spotted Owl (Pancho) Near Fourmile Creek on the Six Rivers National Forest, Humboldt County, California, 12 August 1980 to 24 August 1981. All areas are representative of a mixed evergreen forest (Sawyer et al. 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. The home range area occupied by the female (Lucia) is shown for comparison.

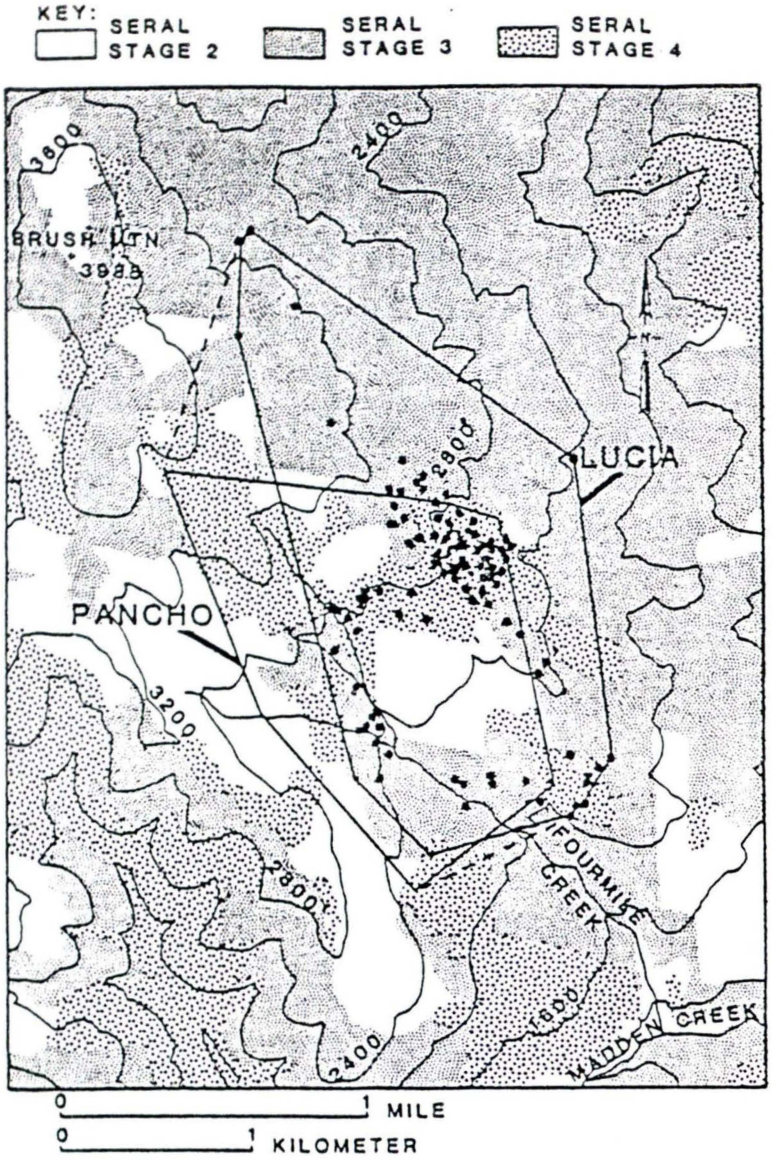


Figure 10. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Adult Female Northern Spotted Owl (Lucia) Near Fourmile Creek on the Six Rivers National Forest, Humboldt County, California, 19 August 1980 to 9 August 1981. All areas are representative of a mixed evergreen forest (Sawyer et al. 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. The home range area occupied by the male (Pancho) is shown for comparison.

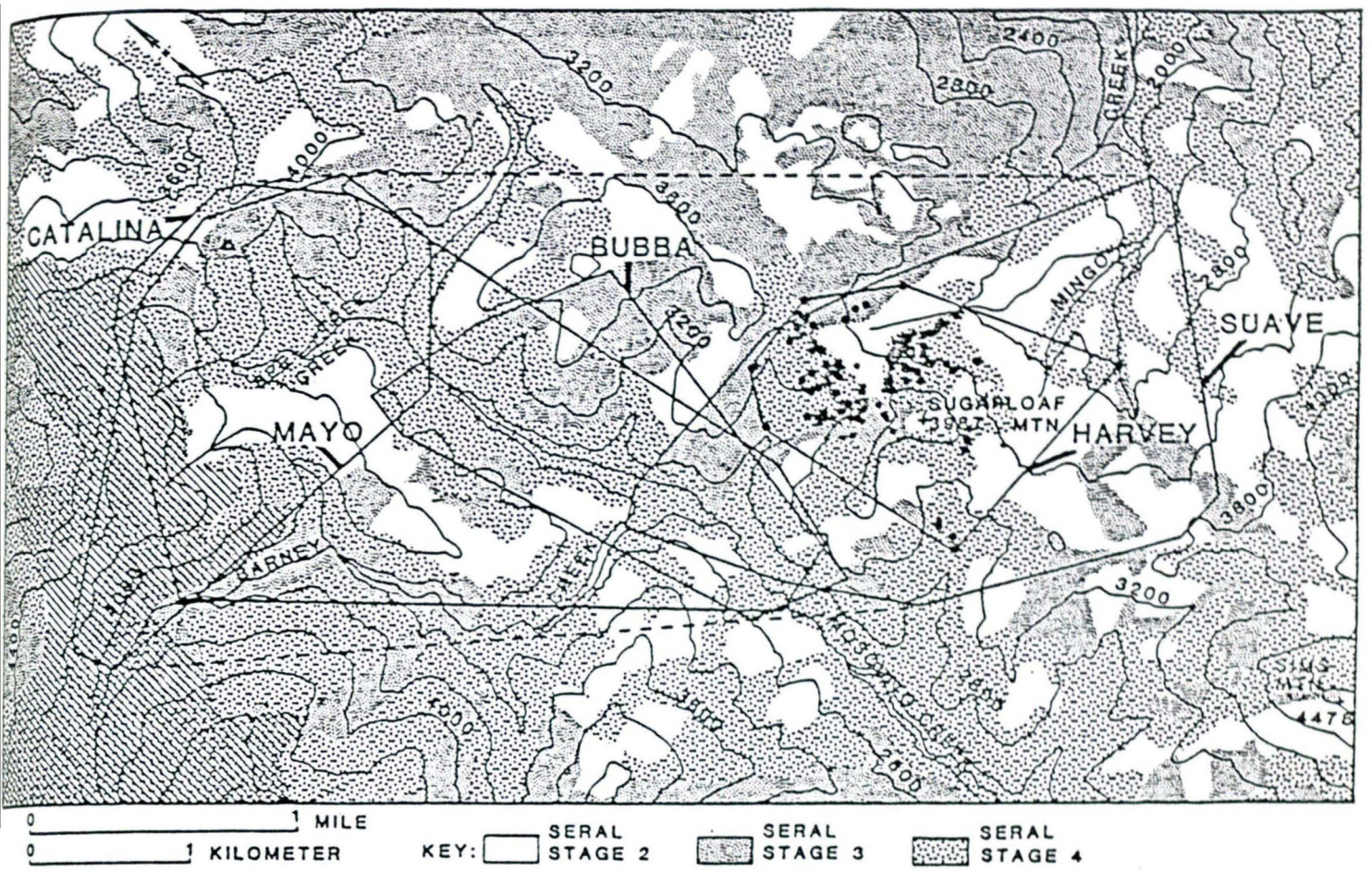


figure 11. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Adult Male Northern Spotted Owl (Harvey) Near Sugarloaf Mountain on the Six Rivers National Forest, Humboldt County, California, 11 March to 12 August 1981. The predominant vegetation is a mixed evergreen forest (Sawyer et al. 1977). The striped area in the lower, left-hand corner of the figure represents a coast range montane forest (Küchler 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Nest locations (open triangles) are indicated. Other home range areas are shown for comparison. Owls are: Catalina (female); Mayo (male); Bubba (male); Suave (female) (see Tables 2-4).

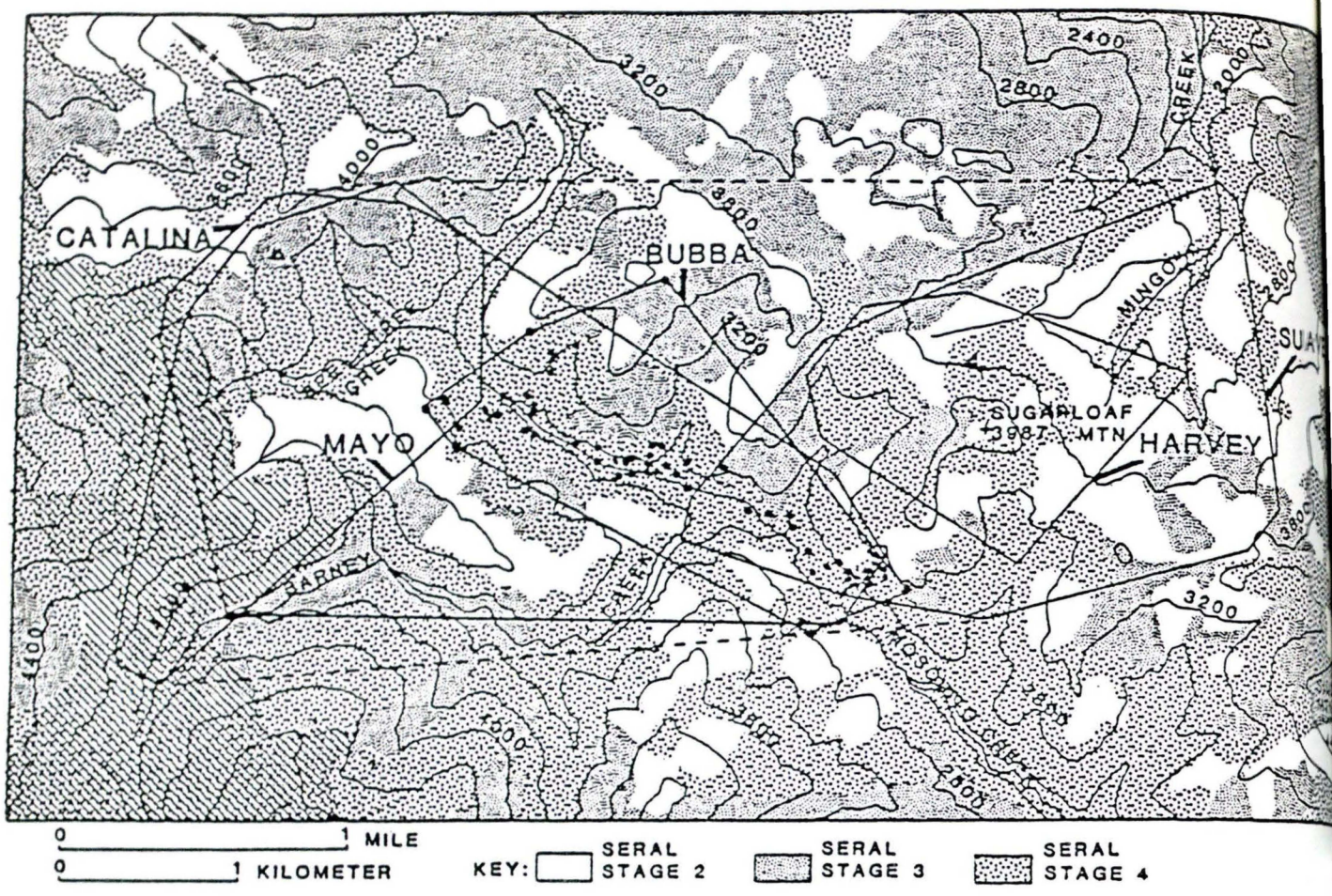


Figure 12. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Adult Male Northern Spotted Owl (Bubba) Near Mosquito Creek on the Six Rivers National Forest, Humboldt County, California, 29 April to 20 June 1981. The predominant vegetation is a mixed evergreen forest (Sawyer et al. 1977). The striped area in the lower, left-hand corner of the figure represents a coast range montane forest (Küchler 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Nest locations (open triangles) are indicated. Other home range areas are shown for comparison. Owls are: Catalina (female); Mayo (male); Harvey (male); Suave (female) (see Tables 2-4).

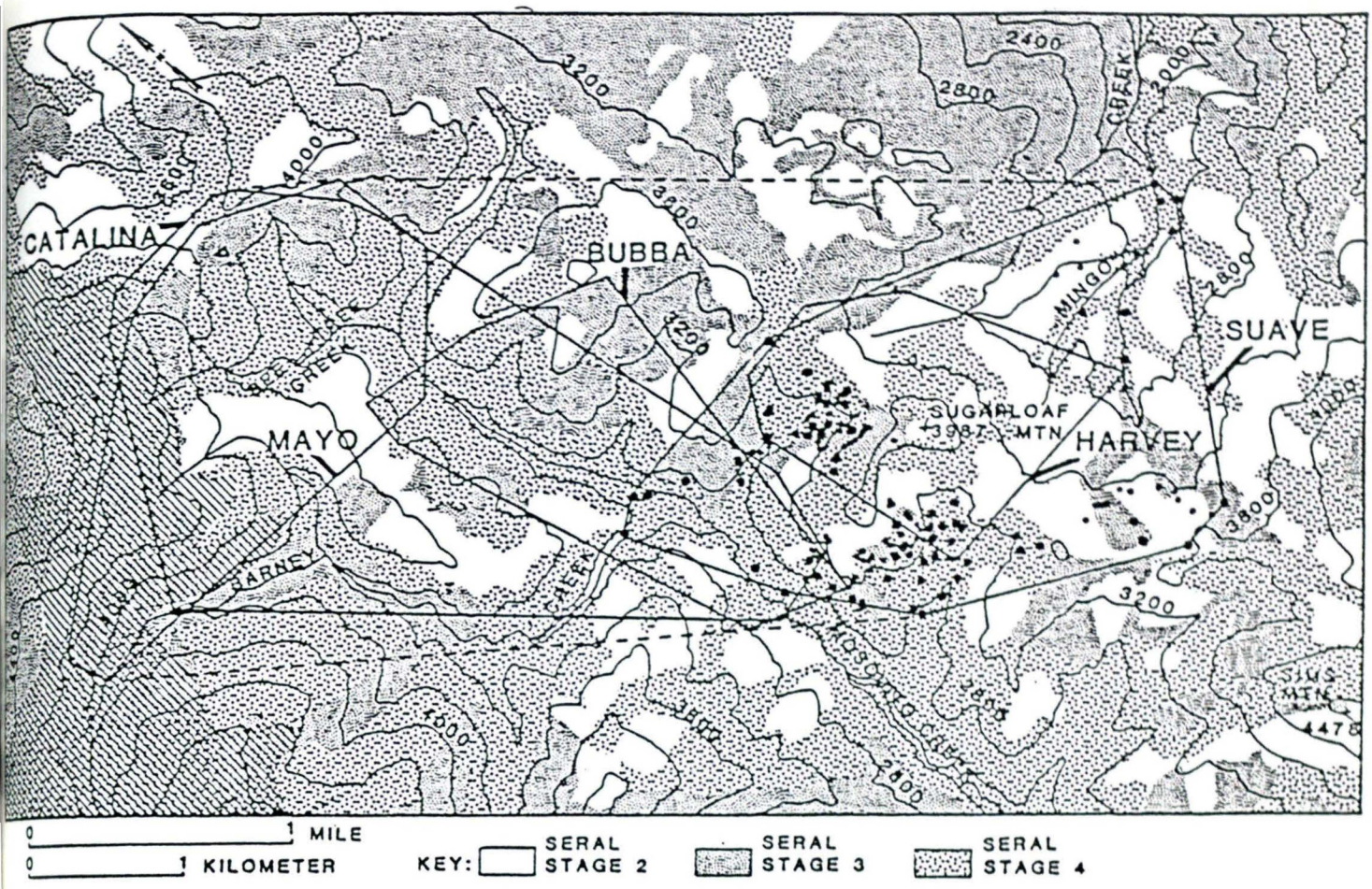


Figure 13. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Immature Female Northern Spotted Owl (Suave) Near Sugarloaf Mountain on the Six Rivers National Forest, Humboldt County, California, 11 March to 12 August 1981. The predominant vegetation is a mixed evergreen forest (Sawyer et al. 1977). The striped area in the lower, left-hand corner of the figure represents a coast range montane forest (Küchler 1977). Seral stages are: seral stage 2 brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Nest locations (open triangles) are indicated. Other home range areas are shown for comparison. Owls are: Catalina (female); Mayo (male); Bubba (male); Harvey (male); (see Tables 2-4).

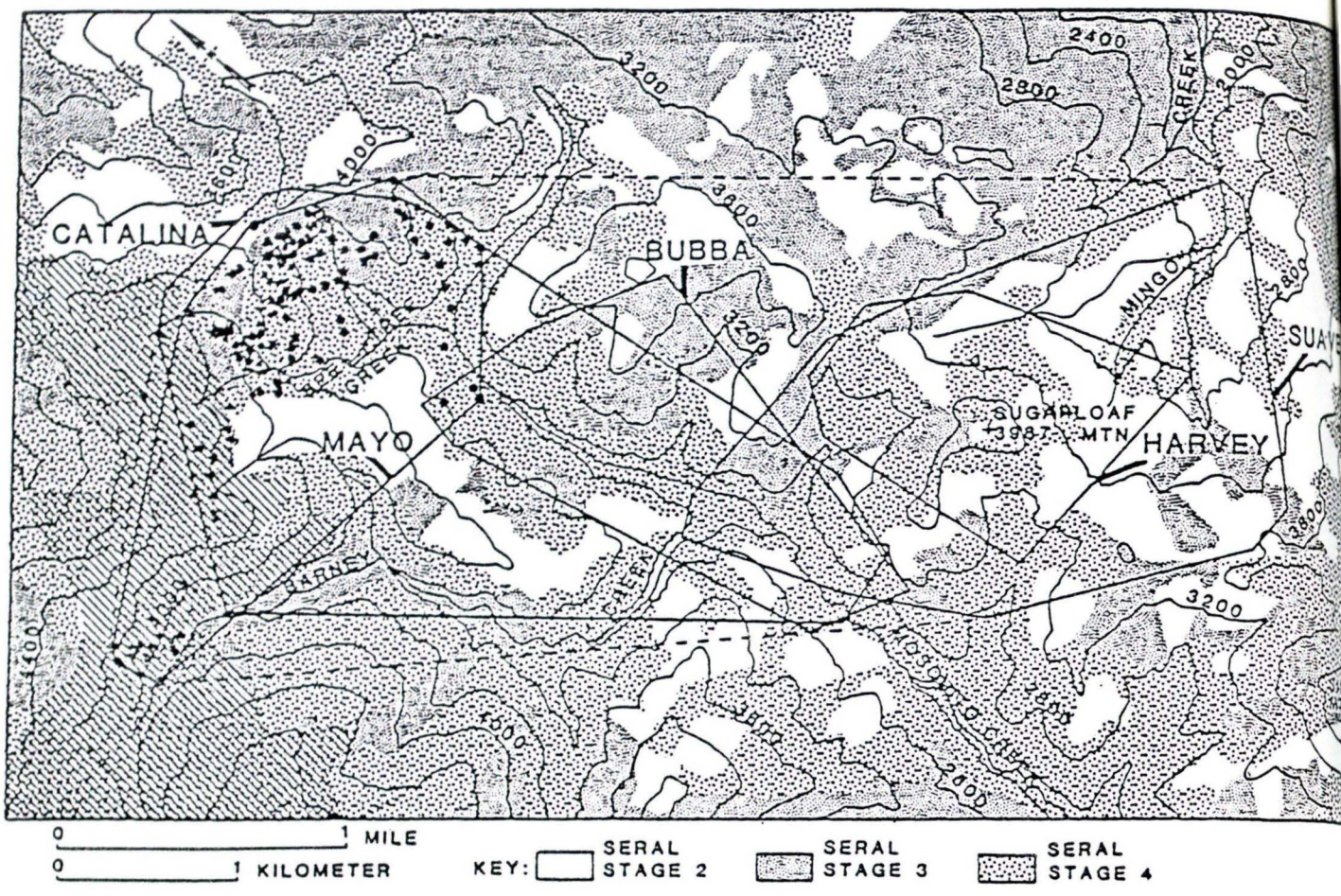


Figure 14. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Adult Male Northern Spotted Owl (Mayo) Near Bee Tree Creek on the Six Rivers National Forest, Humboldt County, California, 12 May to 17 August 1981. The predominant vegetation is a mixed evergreen forest (Sawyer et al. 1977). The striped area in the lower, left-hand corner of the figure represents a coast range montane forest (Küchler 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Nest locations (open triangles) are indicated. Other home range areas are shown for comparison. Owls are: Catalina (female); Bubba (male); Harvey (male); Suave (female) (see Tables 2-4).

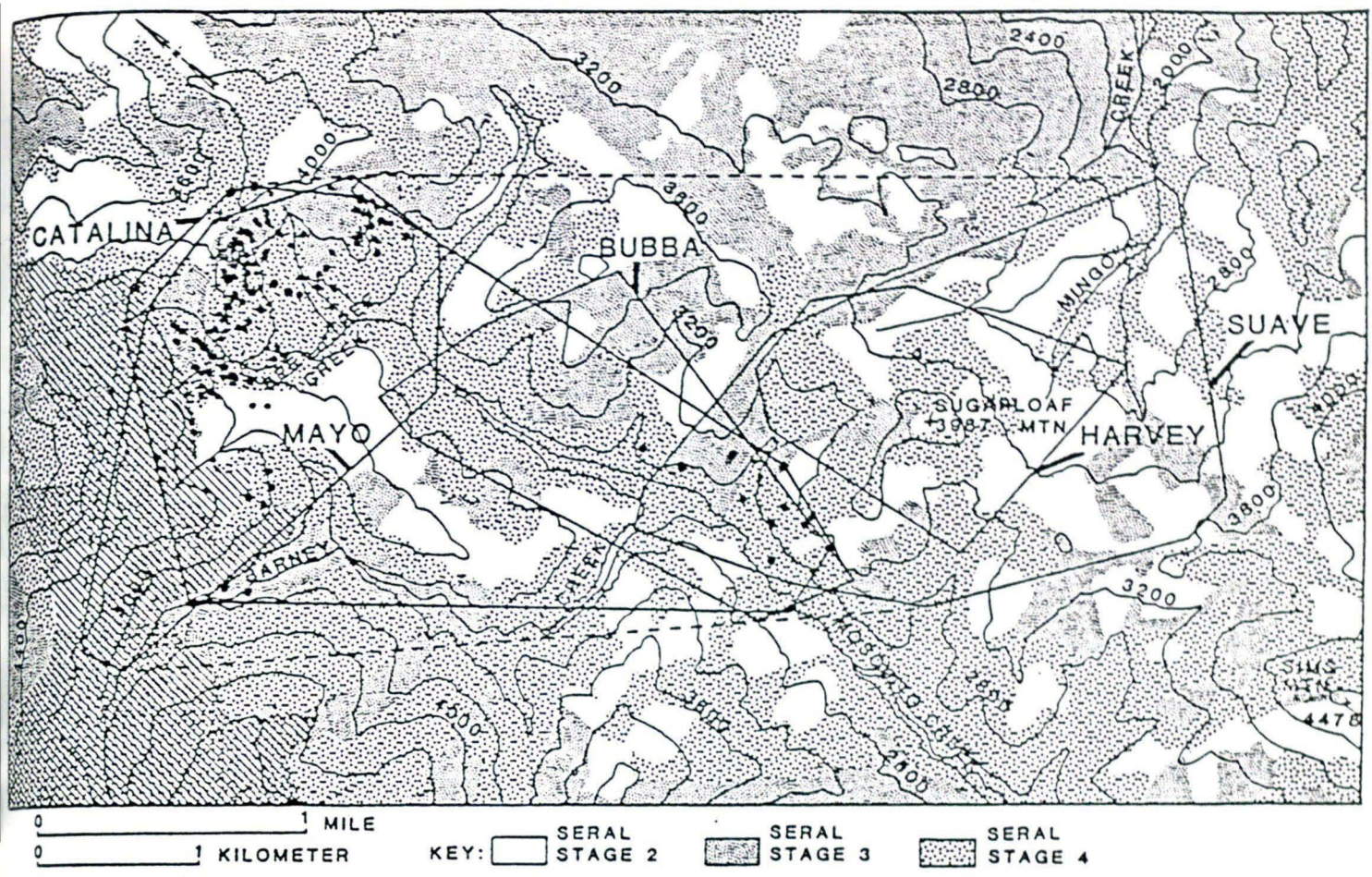


Figure 15. Radio-Telemetry Locations (Foraging and Roosting) Describing the Home Range Area of an Adult Female Northern Spotted Owl (Catalina) Near Bee Tree Creek on the Six Rivers National Forest, Humboldt County, California, 11 May to 17 August 1981. The predominant vegetation is a mixed evergreen forest (Sawyer et al. 1977). The striped area in the lower, left-hand corner of the figure represents a coast range montane forest (Küchler 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Nest locations (open triangles) are indicated. Other home range areas are shown for comparison. Owls are: Mayo (male); Bubba (male); Harvey (male); Suave (female) (see Tables 2-4).

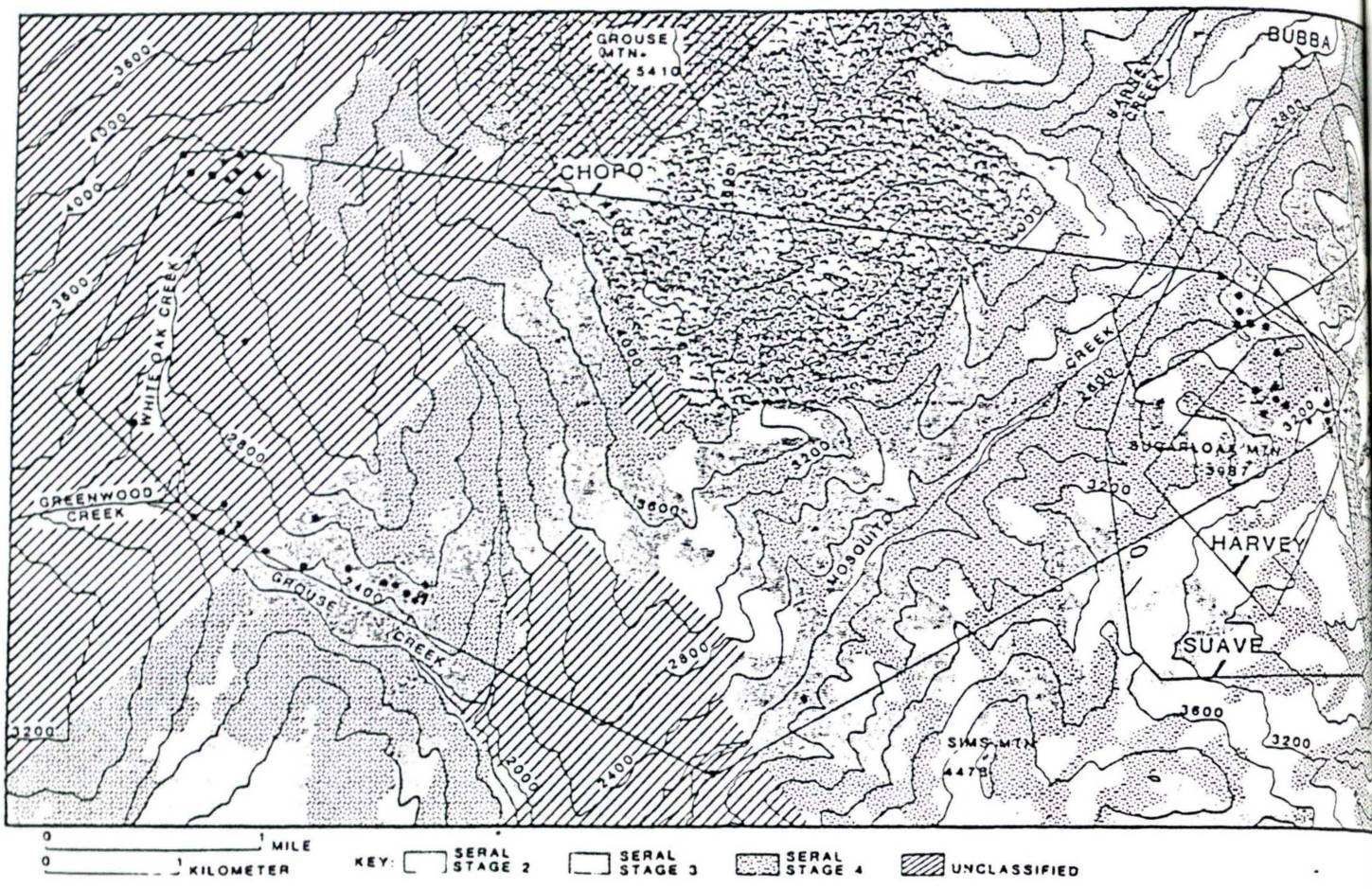


Figure 16. Radio-Telemetry Locations (Foraging and Roosting) Describing the Dispersal Area of an Immature Male Northern Spotted Owl (Chopo) on the Six Rivers National Forest, Humboldt County, California, 5 May to 4 July 1981. The predominant vegetation is a mixed evergreen forest (Sawyer et al. 1977). The shaded area in the upper-center portion of the figure is coast range montane forest (Küchler 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. A nest location (open triangle) is shown. Other home range areas are shown for comparison. Owls are: Bubba (male); Harvey (male); Suave (female) (see Tables 2-1).

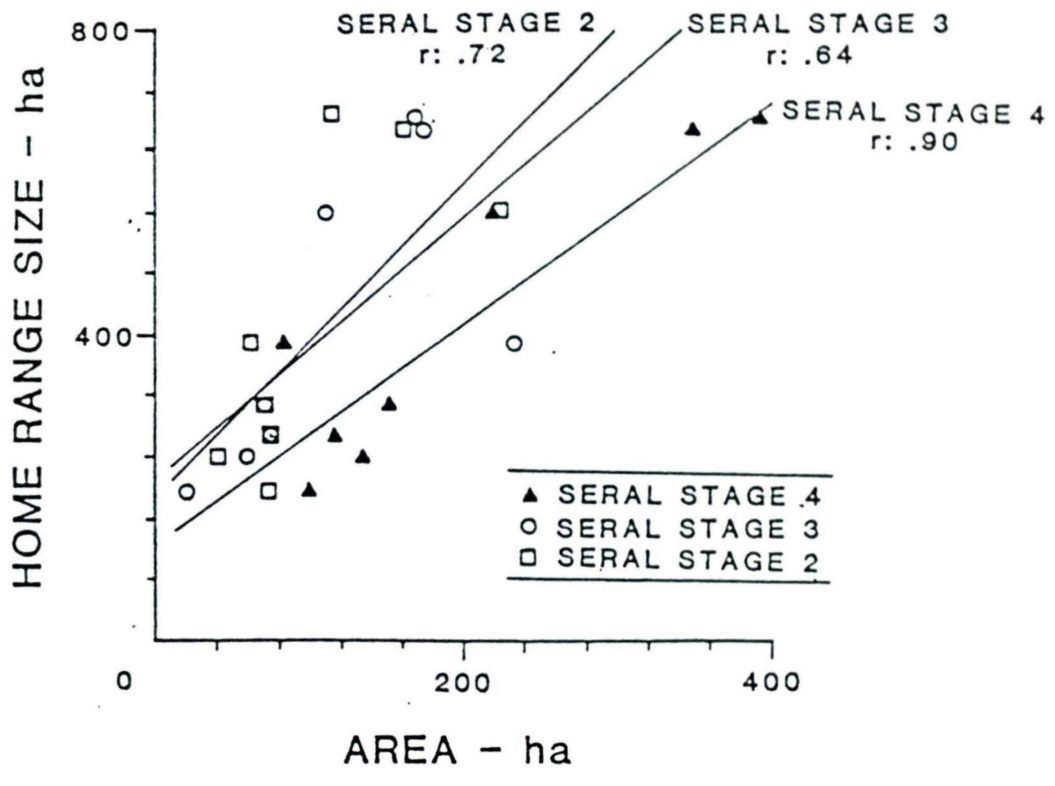


Figure 17. Relationship of Home Range Size to Habitat Availability (Total Area of a Given Seral Stage Within Home Range Boundaries). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979).

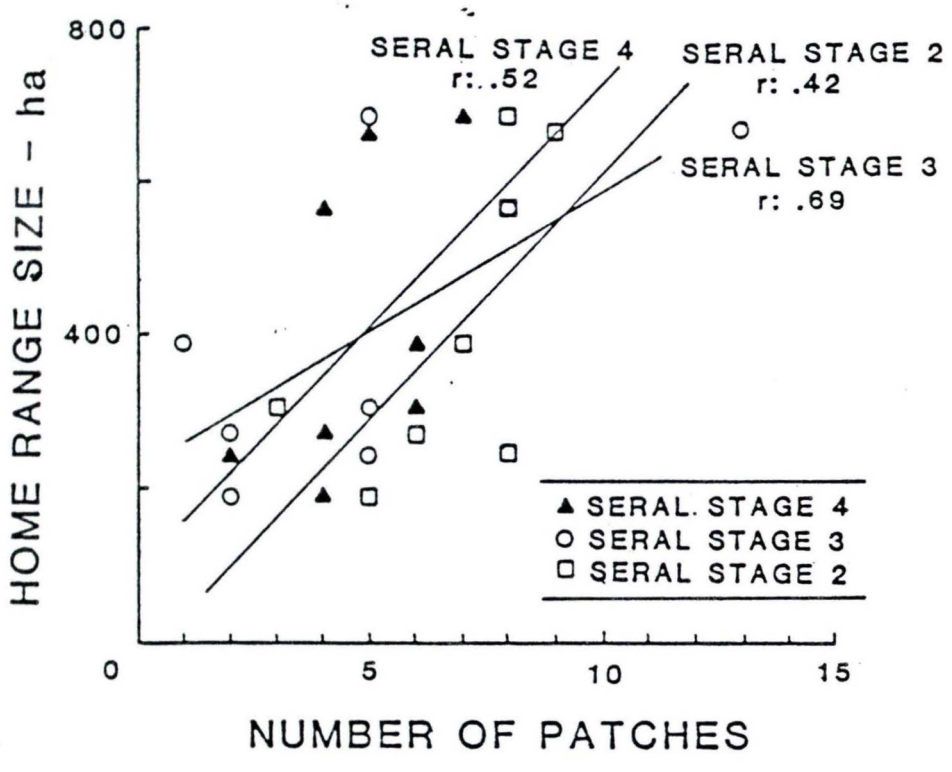


Figure 18. Relationship of Home Range Size to Habitat Patchiness (Total Number of Patches of a Given Seral Stage Within Home Range Boundaries). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature old-growth tree stand) (Marcot 1979).

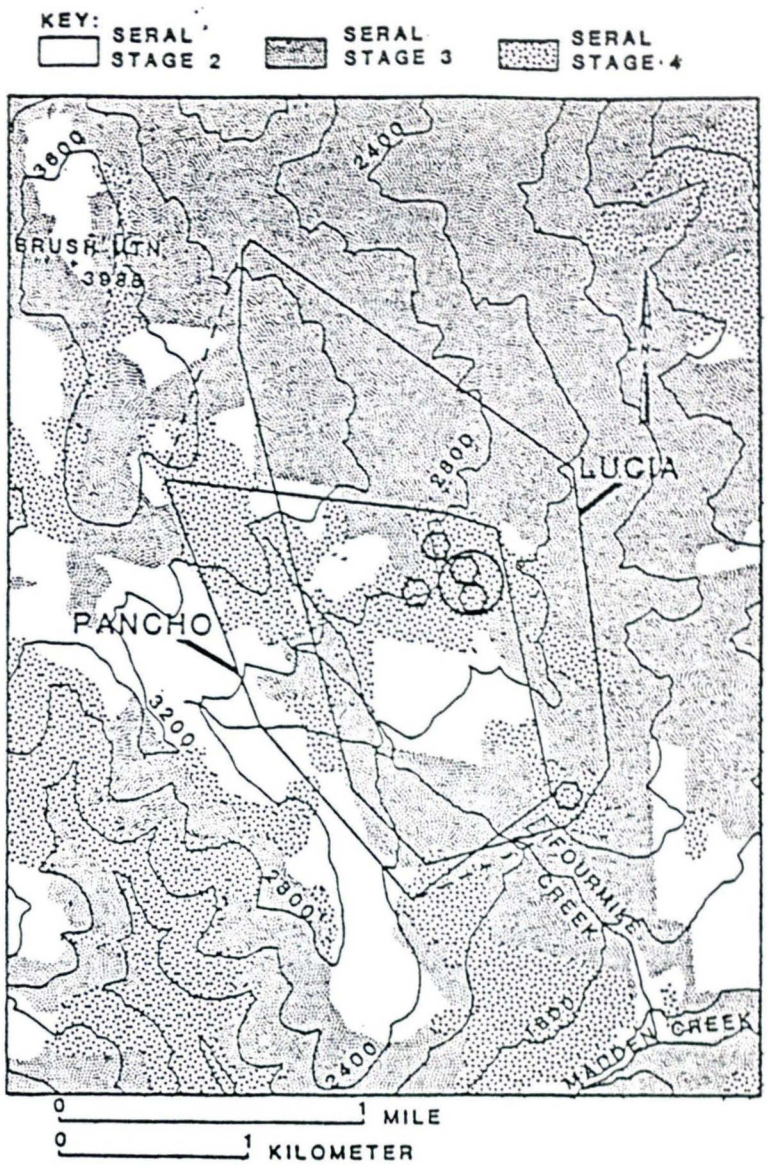


Figure 19. Location of Major Roosting Areas (Open Hexagons) and a Suspected Nesting Area (Open Circle) Within the Fourmile Creek Study Area on the Six Rivers National Forest, Humboldt County, California, 12 August 1980 to 24 August 1981. All Areas are Representative of a Mixed Evergreen Forest (Sawyer et al. 1977). Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Owls are: Pancho (male); Lucia (female) (see Tables 2-4).

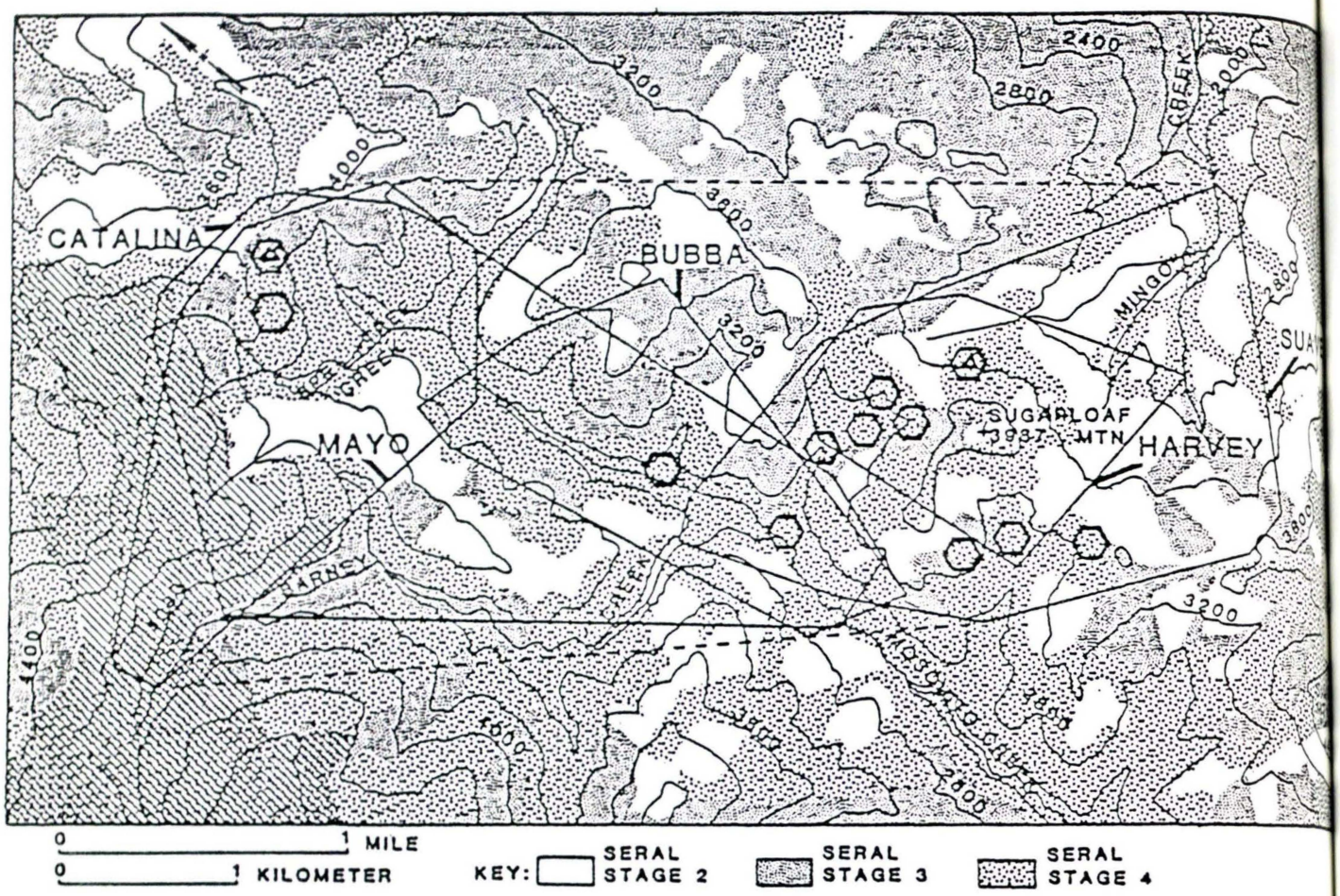


Figure 20. Location of Major Roosting Areas (Open Hexagons) and Verified Nest Sites (Open Triangles) Within the Mosquito Creek Study Area on the Six Rivers National Forest, Humboldt County, California, 11 March to 24 August 1981. The predominant vegetation is a mixed evergreen forest (Sawyer et al. 1977). The striped area in the lower, left-hand corner of the figure is a coast range montane forest (Küchler 1977). Seral stages are: seral stage 2 (brush/seedling/ sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Elevations are in feet. Dashed lines and solid lines represent collective home range boundaries and individual home range areas, respectively. Owls are: Catalina (female); Mayo (male); Bubba (male); Harvey (male); Suave (female) (see Tables 2-4).

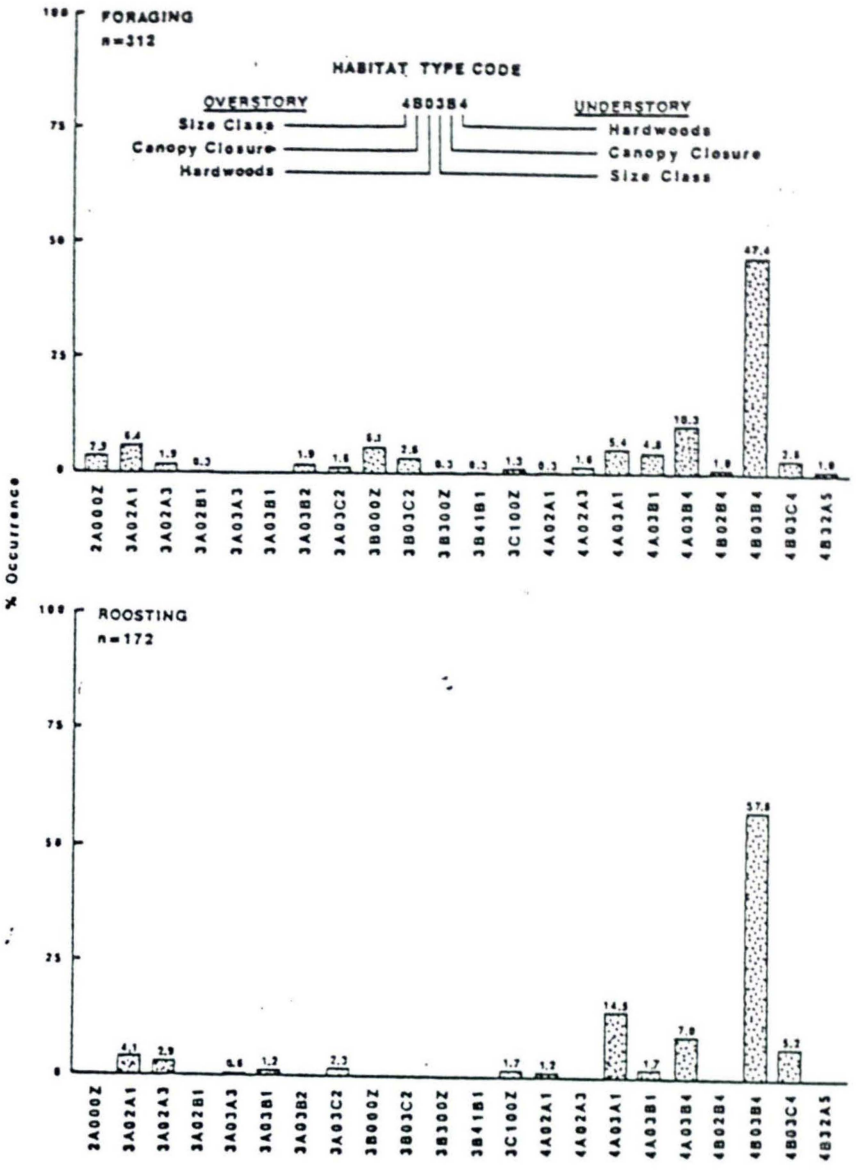


Figure 21. Percent Use of Habitat Types, as Described by Habitat Type Codes, by 8 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1931. Six digit habitat type codes give seral stage, canopy closure, and hardwood component information, both for the overstory and the understory. Seral stages are: seral stage 2 (brush/seedling/sapling tree stand); seral stage 3 (pole/medium tree stand); seral stage 4 (mature/old-growth tree stand) (Marcot 1979). Canopy closures are: A=0-40%; B=40-70%; C=>70%. Hardwood components are: 1=conifers; 2=Oregon white oak, Quercus garryana, California black oak, Quercus kelloggii, and conifers; 3=Oregon white oak and California black oak; 4=tanoak, Lithocarpus densiflorus, and Pacific madrone, Arbutus menziesii, and conifers; 5=tanoak and Pacific madrone; 0 and Z=none.

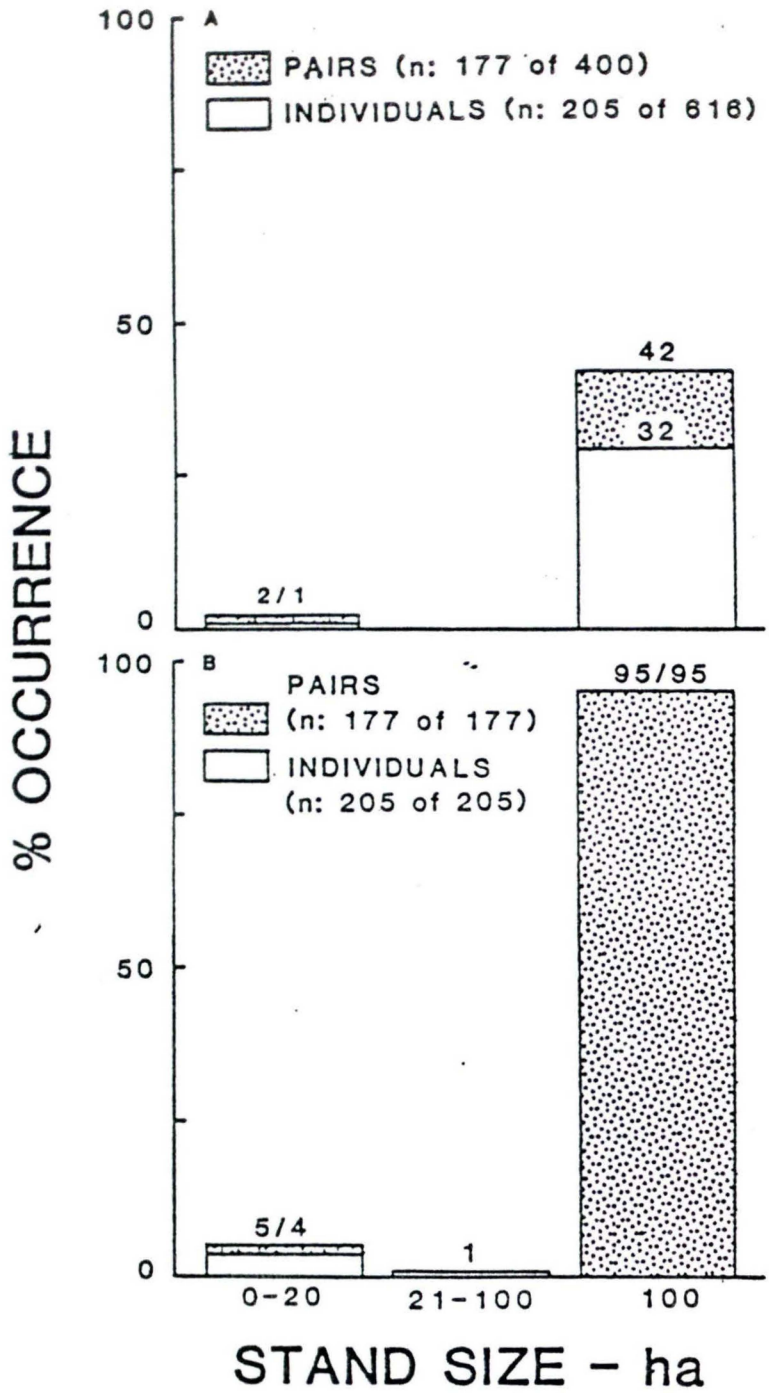


Figure 22. Comparison of Use (Percent Frequency of Occurrence) of Different Size Intervals of Discrete Islands of Mature/Old-Growth Tree Stands (Seral Stage 4; Marcot 1979), Both by Spotted Owl Pairs (n=3) and by Individuals (n=8). Analyses were based on all locations within home range boundaries which were suitable for habitat selection analyses. These locations were described as: (A) occurrences in any habitat type (e.g., seral stage 2 or 3 or 4); (B) occurrences restricted to mature/old-growth timber. Approximate percentage figures are indicated above each bar. Total number of locations for pairs and for individuals appear in the key for each figure.

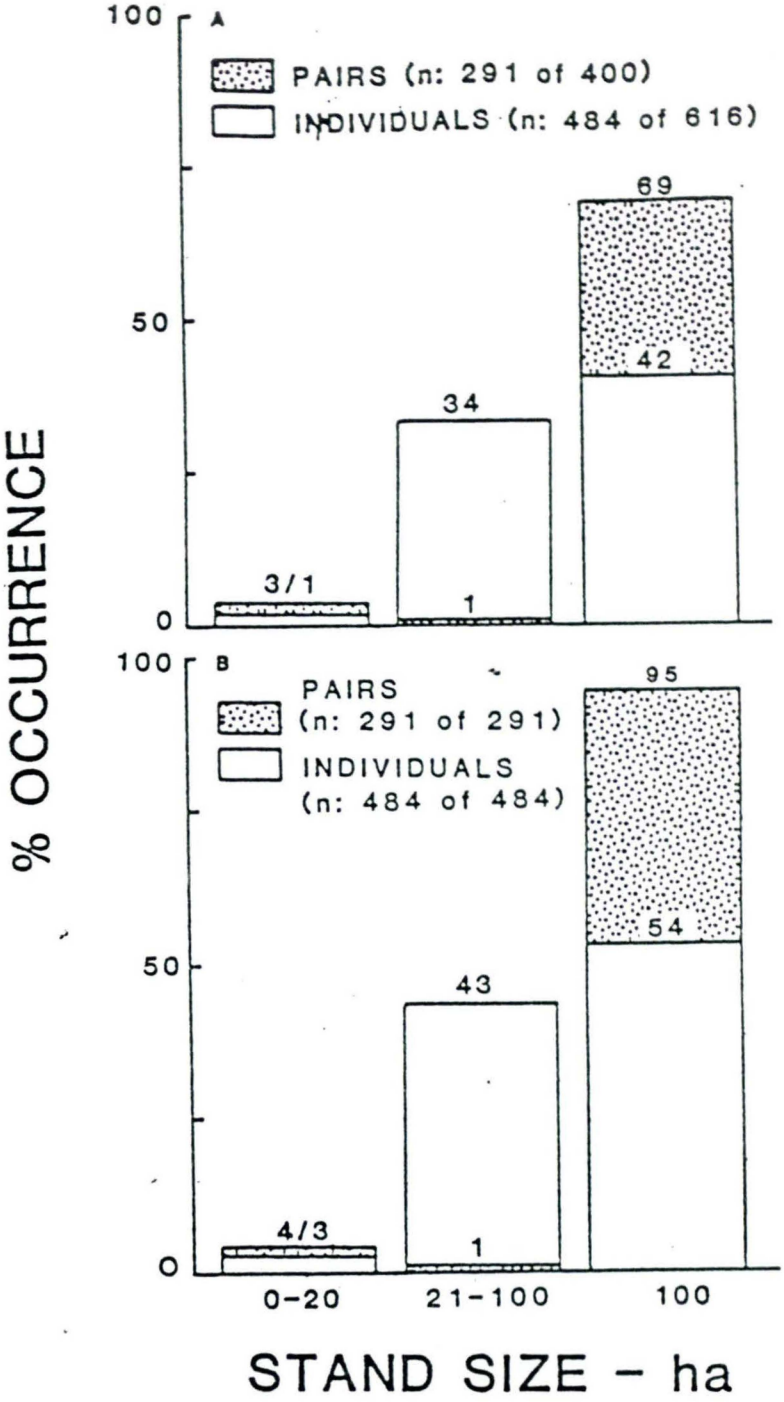


Figure 23. Comparison of Use (Percent Frequency of Occurrence) of Different Size Intervals of Contiguous Stands of Mature/Old-Growth Tree Stands (Seral Stage 4; Marcot 1979), Both by Spotted Owl Pairs (n=3) and by Individuals (n=8). Analyses were based on all locations within home range boundaries which were suitable for habitat selection analyses. These locations were described as: (A) occurrences in any habitat type (e.g., seral stage 2 or 3 or 4); (B) occurrences restricted to mature/old-growth timber. Approximate percentage figures are indicated above each bar. Total number of locations for pairs and for individuals appear in the key for each figure.

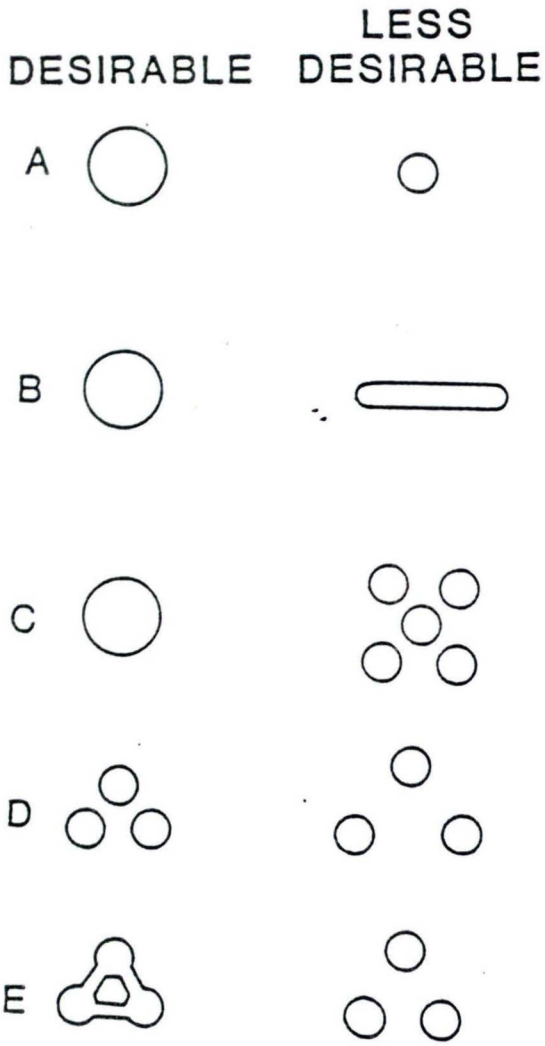


Figure 24. Suggested Arrangements for Habitat Areas: (A) a Larger Habitat Area is Better Than a Smaller Habitat Area; (B) a Continuous Habitat Area Should be Cirular; (C) a Continuous Habitat Area is Better Than a Fragmented One; (D) Fragmented Habitat Areas Should be Close and Equally Spaced; (E) Fragmented Habitat Areas Should be Connected by Corridors of Suitable Habitat (after Diamond 1974, 1975; Terborgh 1974; Willson and Willis 1975).

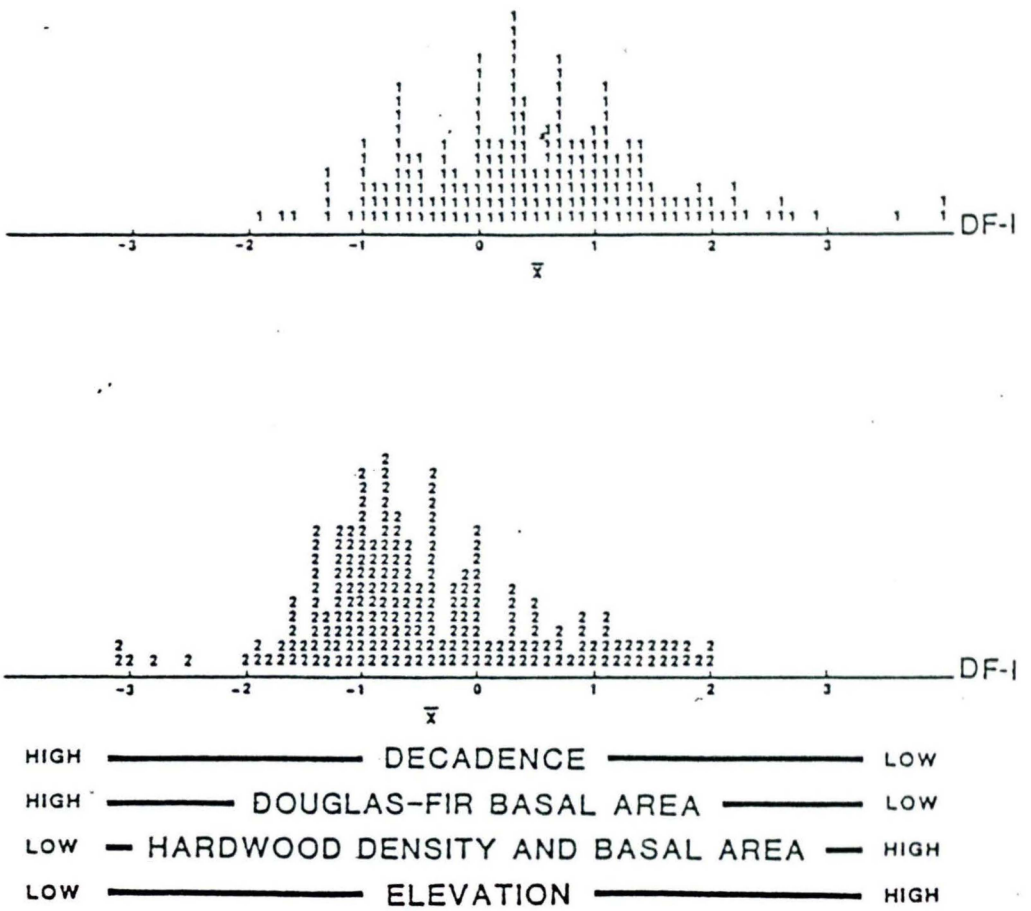


Figure 25. One Dimensional Ordination of (1) Male and (2) Female Northern Spotted Owl Habitats (Roost, Core, and Non-Core Combined) With Respect to the First Discriminant Function Axis (DF-I). Habitats are: roost, verified roost locations; core, an aggregation of timber stand polygons accounting for greater than 55% of an owl's total number of foraging locations; non-core, area exclusive of core area. Discriminant group means ($\bar{X}$) are identified.

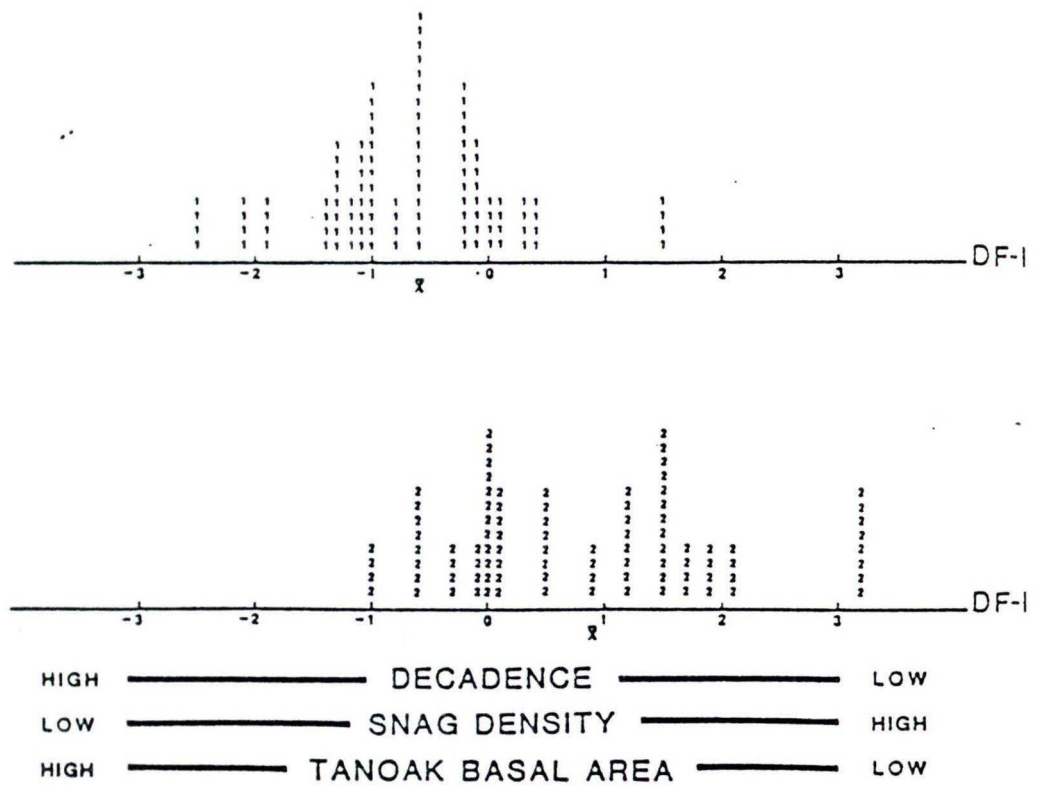


Figure 26. One Dimensional Ordination of (1) Male and (2) Female Northern Spotted Owl Roost Habitats With Respect to the First Discriminant Function Axis (DF-I). Roosts are verified roost locations. Discriminant group means ($\bar{X}$) are identified.

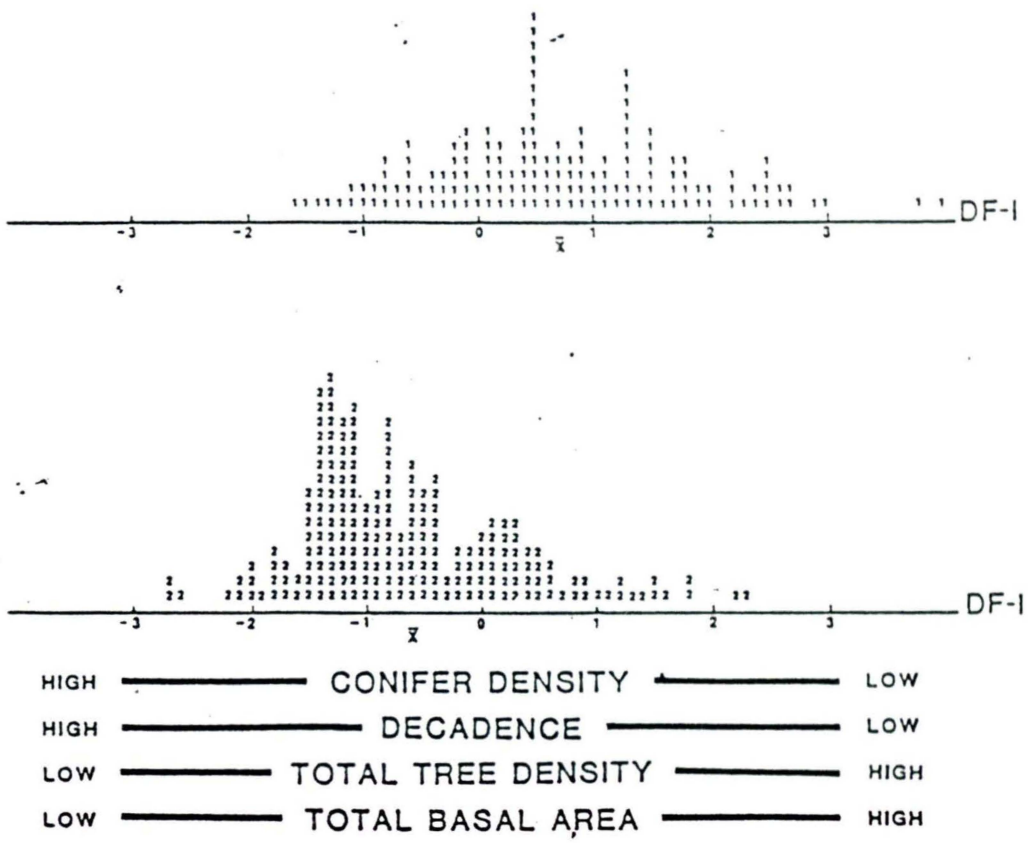


Figure 27. One Dimensional Ordination of (1) Male and (2) Female Northern Spotted Owl Core Habitats With Respect to the First Discriminant Function Axis (DF-I). Core habitats represent an aggregation of timber stand polygons accounting for greater than 55% of an owl's total number of foraging locations. Discriminant group means ($\bar{X}$) are identified.

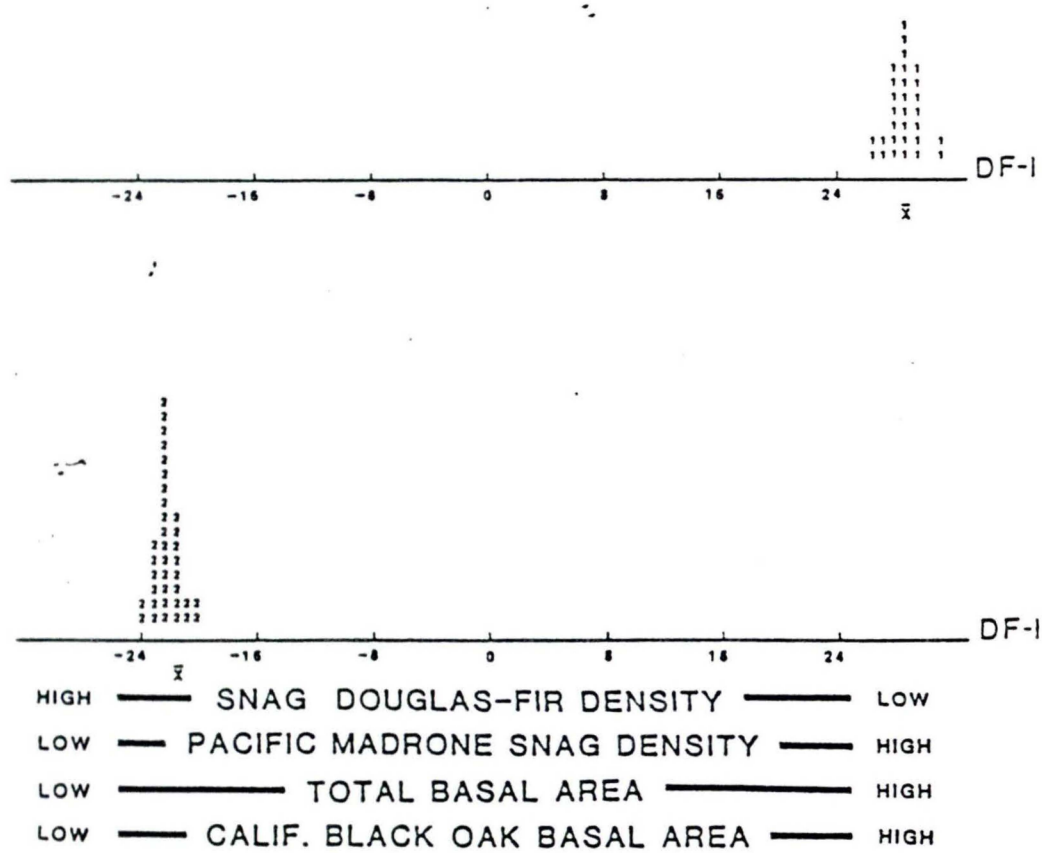


Figure 28. One Dimensional Ordination of (1) Male and (2) Female Northern Spotted Owl Non-Core Habitats With Respect to the First Discriminant Function Axis (DF-I). Non-core habitats represent an aggregation of timber stand polygons accounting for less than 55% of an owl's total number of foraging locations. Discriminant group means ($\bar{X}$) are identified.

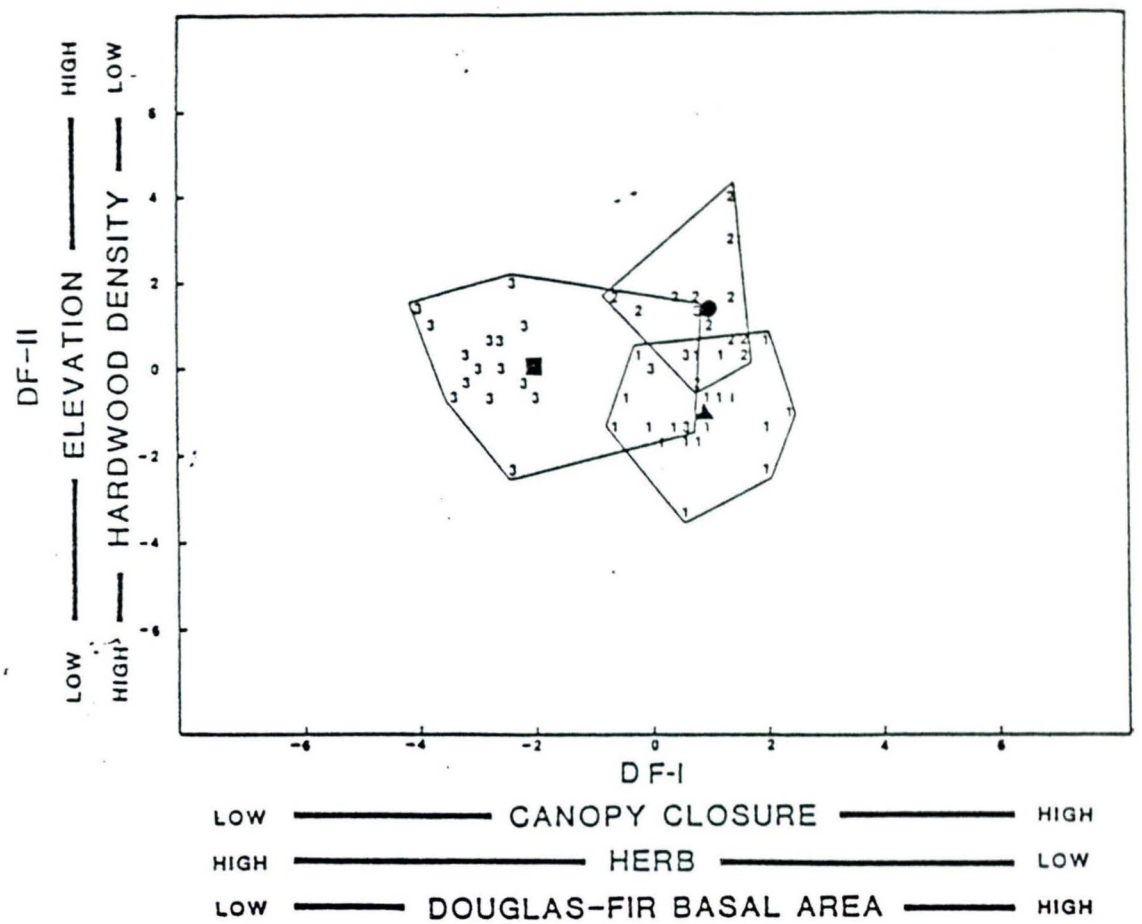

DF-II
LOW ——— ELEVATION ——— HIGH
HIGH ——— HARDWOOD DENSITY ——— LOW
DF-I
LOW ——— CANOPY CLOSURE ——— HIGH
HIGH ——— HERB ——— LOW
LOW ——— DOUGLAS-FIR BASAL AREA ——— HIGH

Figure 29. Two Dimensional Ordination of Female Northern Spotted Owl Habitats With Respect to the First and Second Discriminant Function Axes, DF-I and DF-II, Respectively. Habitats are: roost, verified roost locations; core, an aggregation of timber stand polygons accounting for greater than 55% of an owl's total number of foraging locations; non-core, area exclusive of core area. Discriminant group means are: ▲=roost; ●=core; ■=non-core.

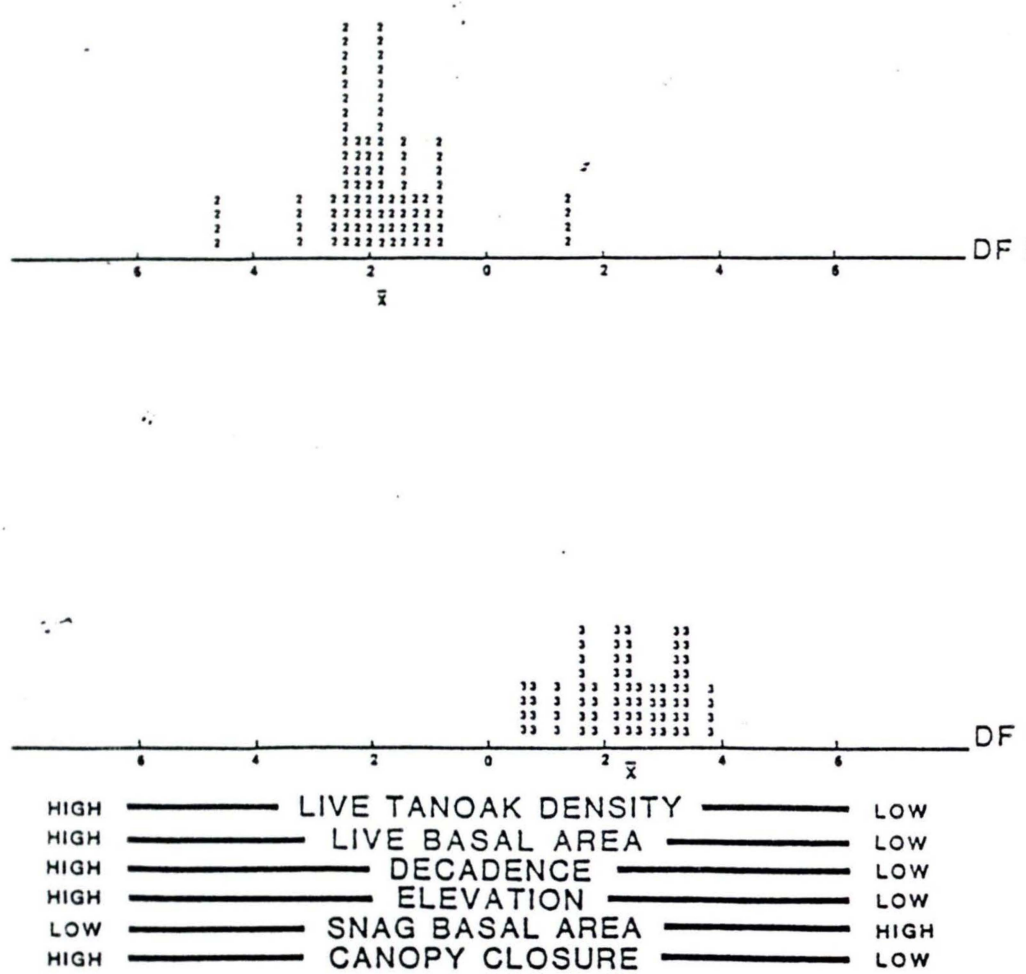


Figure 30. One Dimensional Ordination of Female Northern Spotted Owl Foraging Habitats With Respect to the first Discriminant Function Axis (DF-I). Foraging habitats are: (2) core, an aggregation of timber stand polygons accounting for greater than 55% of an owl's total number of foraging locations; (3) non-core, area exclusive of core area. Discriminant group means ($\bar{X}$) are identified.

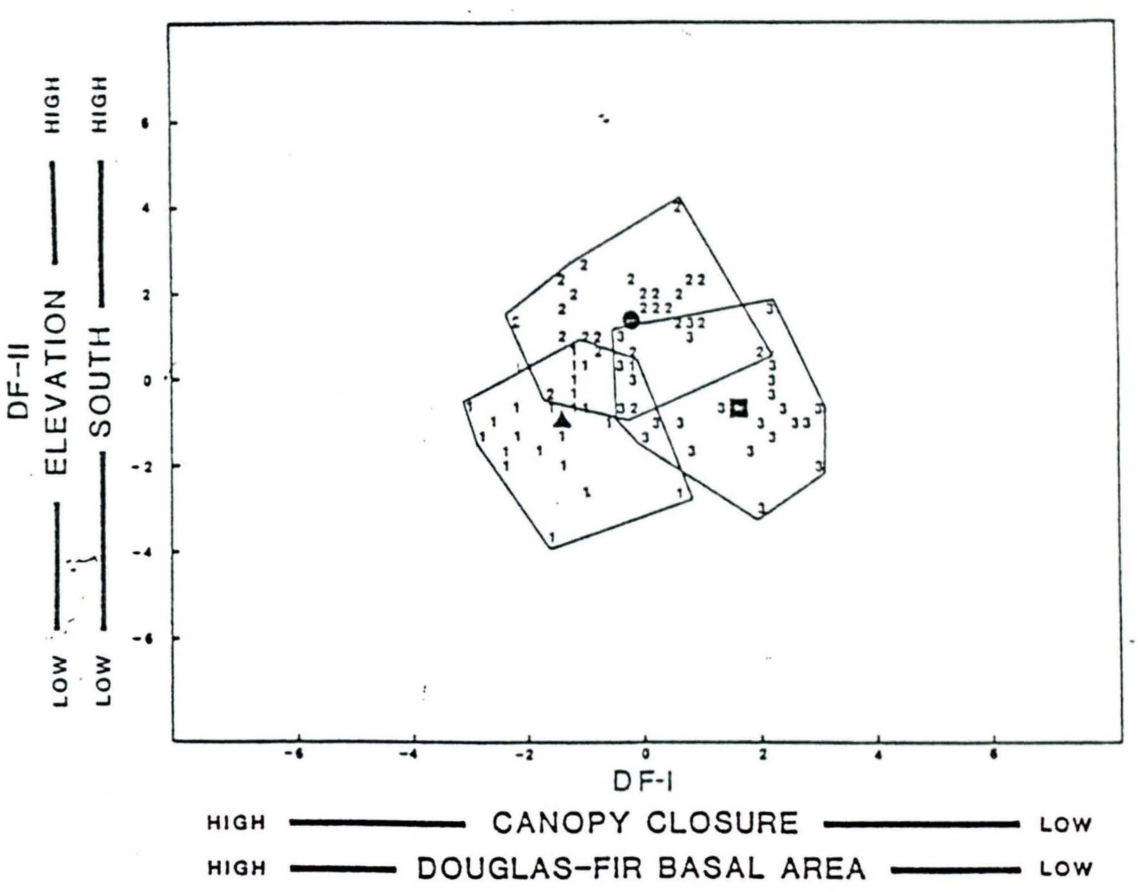


Figure 31. Two Dimensional Ordination of Male Northern Spotted Owl Habitats With Respect to the First and Second Discriminant Function Axes, DF-I and DF-II, Respectively. Habitats are: roost, verified roost locations; core, an aggregation of timber stand polygons accounting for greater than 55% of an owl's total number of foraging locations; non-core, area exclusive of core area. Discriminant group means are: ▲=roost; ●=core; ■=non-core.

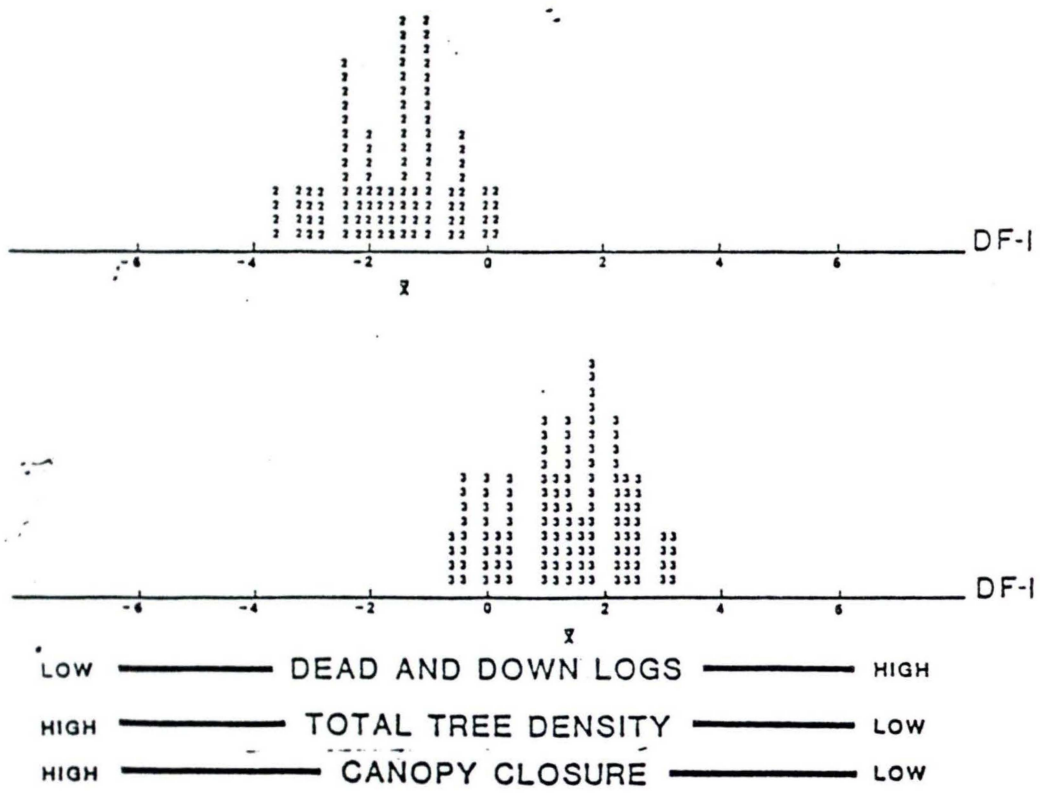


Figure 32. One Dimensional Ordination of Male Northern Spotted Owl foraging Habitats With Respect to the First Discriminant Function Axis (DF-I). Foraging habitats are: (2) core, an aggregation of timber stand polygons accounting for greater than 55% of an owl's total number of foraging locations; (3) non-core, area exclusive of core area. Discriminant group means ($\bar{X}$) are identified.

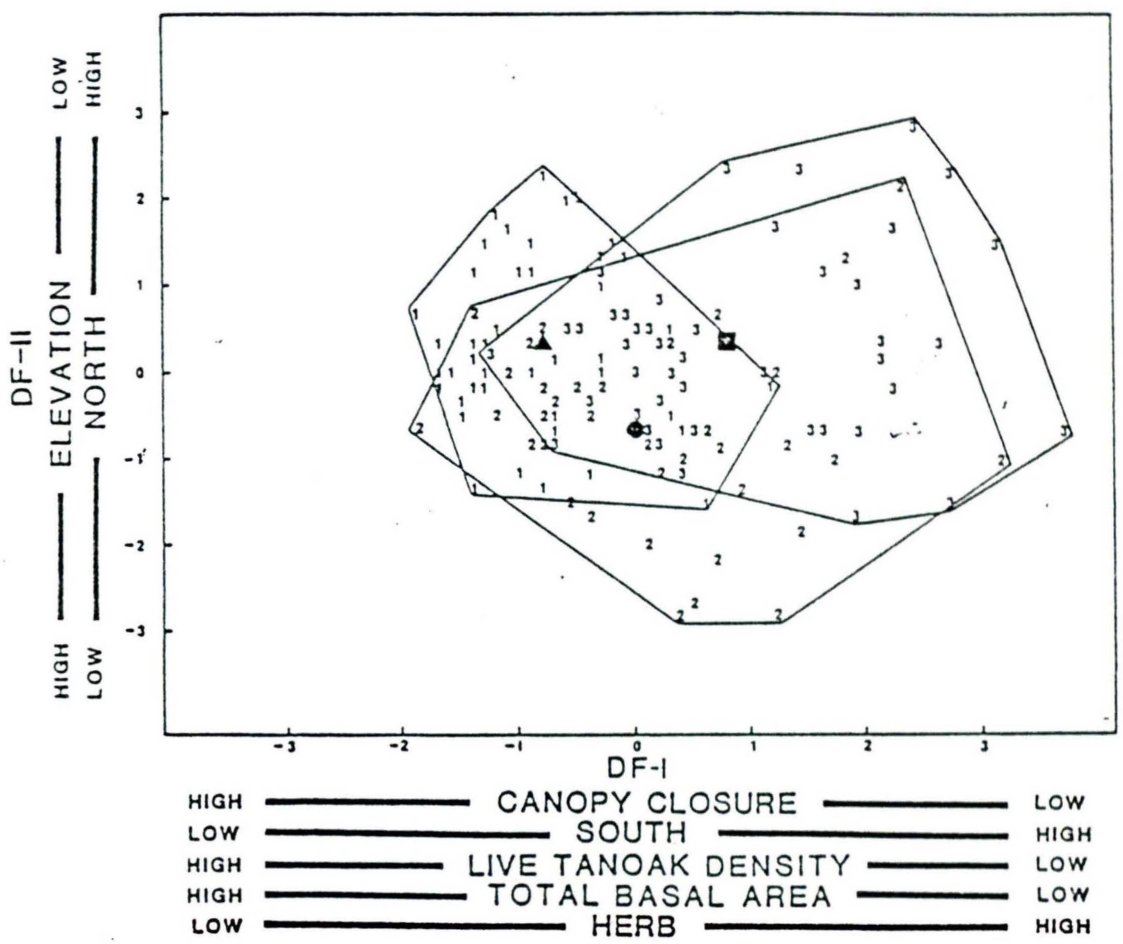


Figure 33. Two Dimensional Ordination of Northern Spotted Owl Habitats (Sexes Combined) With Respect to the First and Second Discriminant Function Axes, DF-I and DF-II, Respectively. Habitats are: (1) roost, verified roost locations; core, an aggregation of timber stand polygons accounting for greater than 55% of an owl's total number of foraging loations; non-core, area exclusive of core area. Discriminant group means are: ▲=roost; ●=core; ■=non-core.

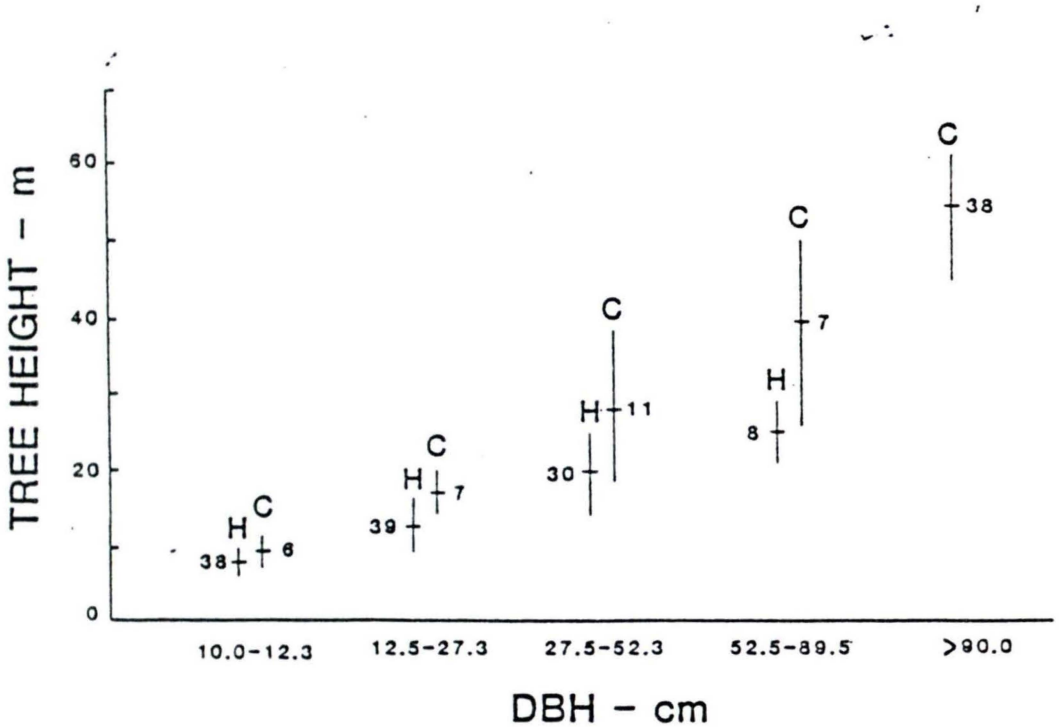


Figure 34. Hardwood (H) and Conifer (C) Tree Heights for Roost Habitats (Sexes Combined) by Diameter at Breast Height (DBH) Interval. Horizontal line represents the mean of means. Vertical line represents the standard deviation. Sample sizes are indicated next to each mean.

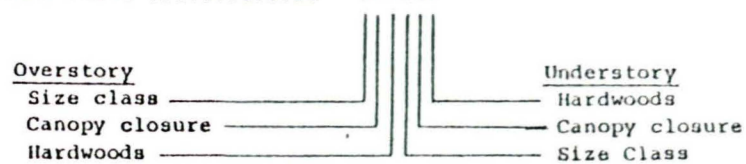
Table 1. A Comparison of Habitat Information from the Six Rivers National Forest Wildland and Resource Information System (WRIS) Timber Stand Classification System and the California/Wildlife Habitat Relationships (WHR) Program (North Coast/Cascade Zone) (Marcot 1979) Used to Construct Habitat Type (HT) Codes. HT codes give seral stage, canopy closure, and hardwood component information for both overstory and understory. Six-digit HT codes were constructed by interpreting WRIS timber stand map information, and then choosing the appropriate alpha/numerical code appearing under the asterisk, left to right across the table.

Overstory Size Class		Overstory Canopy Closure		Overstory Hardwood		Understory Size Class		Understory Canopy Closure		Understory Hardwood	
* WRIS	* WHR	WRIS	* WHR	*		WRIS	* WHR	WRIS	* WHR	*	
	1 Grass/ Forb	-,=	A 0-40%	1	Oregon Oak Black Oak Conifer		1 Grass/ Forb	-,=	A 0-40%	1	Conifer
1	2 Brush/ Sapling	=	B 40-70%	2	Oregon Oak Black Oak	1	2 Brush/ Sapling	=	B 40-70%	2	Oregon Oak Black Oak Conifer
2,3	3 Pole/ Medium Tree	=	C 70% +	3	Tanoak Madrone/ Conifer	2,3	3 Pole/ Medium Tree	=	C 70% +	3	Oregon Oak Black Oak
4,5	4 Mature/ Old-growth Tree			4	Tanoak Madrone	4,5	4 Mature/ Old-growth Tree			4	Tanoak Madrone/ Conifer
										5	Tanoak Madrone
				0	Conifer		0 None		0 None	Z	None
*WHT code sequence: First digit		Second digit		Third digit		Fourth digit		Fifth digit		Sixth digit	

An example of WRIS/WHR interface:

WRIS timber stand label ..... DTOM3-/D1=

WHT code label 3A32A1



APPENDIXES

Appendix A. Glossary.

Throughout this paper, the breeding season (1 February to 1 October) is the time period from nest site selection to when owlets (young owls) are independent of the adults, and the nonbreeding season is the time period exclusive of the breeding season. Dates used to denote the breeding season follow Forsman (1976), although they are somewhat arbitrary since each phase of the breeding chronology exhibits a range.

Canopy closure, as measured by a spherical densiometer, is the percentage of open space occupied by all tree layers in a timber stand. Canopy closure, as indicated by habitat type codes, refer to the percent of open space occupied by the overstory or understory, independently. Overstory refers to the uppermost layer in a multilayered forest, and the understory is the brush or tree layer found under the canopy of taller trees (U.S. Forest Service 1982).

Developmental or successional stages within a biological community or ecosystem are seral stages (U.S. Forest Service 1982). Three seral stages are recognized: seral stage 2 (brush/seedling/sapling tree stands), which vary in canopy closure, are generally less than 12.5 cm (5.0 in) DBH, and range from 0 to 15 years in age; seral stage 3 (pole/medium tree stands), which vary in canopy closure, range in DBH from 12.5 to 52.3 cm (5.0 to 20.9 in), and are between 15 and 70 years in age; and seral stage 4 (mature/

old-growth tree stands), which vary in canopy closure and are generally greater than 52.5 cm (21.0 in) DBH and 70 years in age (Marcot 1979; U.S. Forest Service 1982). Old-growth stands are generally older than 200 years in age, are greater than 90.0 cm (36 in) DBH, and show decadent characteristics (U.S. Forest Service 1982).

A polygon is a land management planning, basic mapping unit which is primarily based on timber type (see Table 1 for Wildland Resource Information System (WRIS) timber stand information descriptions) (U.S. Forest Service 1982). A core area is an aggregation of polygons within each owl's home range which accounted for greater than 55 percent of each owl's total number of foraging locations, as determined by radio-telemetry. Non-core area is the area within each owl's home range area exclusive of the core area.

Inner-gorge areas are inherently unstable, steep slopes (greater than 65 percent slope gradient) adjacent to river or stream channels and extending from the channel to the first significant break in slope (generally greater than 15 percent slope) (U.S. Forest Service 1982). Riparian areas include at least the land and vegetation within approximately 30 m (100 ft) on either side of perennial streams or other bodies of water (U.S. Forest Service 1982). Corridors are defined as any forest stands which connect areas that are intensively used by owls for foraging or roosting and whose primary functions are to facilitate their movements between these areas, regardless of width.

An owl's home range area refers to the collective area used by an owl for nesting, foraging, or roosting. A collective home range area is the total area used by two or more owls for foraging, nesting, or roosting, as defined by the minimum polygon method. A dispersal area is an area used by an owl for movements away from an area of high population density or from a birthplace (Brown 1975).

Finally, differences between the concept of a home range area and a territory should be emphasized because they are not identical. This paper generally describes home range area characteristics. Parts or all of a home range area may or may not be defended. Home range areas may or may not overlap. Territories are fixed areas from which intruders are excluded by threat, attack, or advertisement (e.g. vocalizations) (Brown 1975).

Appendix B. Banding Information.

Table 1. Banding Information for 10 Northern Spotted Owls Captured on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 Aug. 1981.

Owl Code	U.S. Fish and Wildlife Service metal leg band (number-tarsi)	Plastic leg band (color-tarsi)
Uno	none	none
Pancho	none	none
Lucia	none	none
Nieve	none	none
Harvey	09709221-Right	White-Left
Bubba	none	none
Suave	99709227-Left	none
Chopo	99709224-Right	White-Left
Mayo	99709230-Left	Red-Right
Catalina	99709229-Right	Blue-Left

Appendix C. Sampling Methodology.

Table 1. Acronyms, Descriptions, and Sampling Methods for Roost Site Variables (after Forsman 1980).

Acronym	Variable descriptions	Methods
1) HTABGND	Owl height above ground (m)	Measured using a Relaskop or clinometer.
2) DISTRNK	Owl distance to trunk of roost tree (m)	Distance projected to the ground and measured horizon tally using a measuring tape
3) DISEDGE	Owl distance to edge of roost tree (m)	Same as 2.
4) OOPEN	Immediate protection afforded to an owl by overhead leaves, branches, or trunks (open, 0-10% closure)	Estimated using printed crown density scales (Avery 1978) as references.
5) OSPARSE	Same as 4, (sparse, 10-40% closure)	Same as 4.
6) OMOD	Same as 4, (moderate, 40-70% closure)	Same as 4.
7) ODENSE	Same as 4, (dense, greater than 70% closure)	Same as 4.
8) SOPEN	Immediate protection afforded to an owl by lateral leaves, branches, or trunks (open, 0-10% closure)	Same as 4.
9) SSPARSE	Same as 8, (sparse, 0-10% closure)	Same as 4.
10) SMOD	Same as 8, (moderate, 40-70% closure)	Same as 4.
11) SDENSE	Same as 8, (dense, greater than 70% closure)	Same as 4.
12) DF	Roost tree species is Douglas-fir, Pseudotsuga menziesii	Visual identification.
13) TOAK	Roost tree species is tanoak, Lithocarpus densiflorus	Same as 12.
14) MAD	Roost tree species is Pacific madrone, Arbutus menziesii	Same as 12.
15) CLO	Roost tree species is canyon-live oak, Quercus chrysolepis	Same as 12.
16) CBO	Roost tree species is California black oak, Quercus kelloggii	Same as 12.
17) PD	Roost tree species is Pacific dogwood, Cornus nuttallii	Same as 12.
18) BLM	Roost tree species is big-leaf maple, Acer macrophyllum	Same as 12.
19) RTDBH	Roost tree diameter at breast height (DBH) (cm)	Measured to the nearest 2.5 cm (1.0 in) using a DBH tape.
20) RTHT	Roost tree height (m)	Same as 1.

Table 1 (continued).

Acronym	Variable descriptions	Methods
21) CCLOS	Average percent total canopy closure	Estimated using a spherical densiometer, four readings taken 4.6 m (15.0 ft) from the roost tree, one at each major cardinal heading, then averaged.
22) OVSTYHT	Average overstory height (m)	Same as 1, three trees measured then averaged.
23) USTYHT	Average understory height (m)	Same as 1, three trees measured then averaged
24) PSLOPE	Average percent slope	Same as 1, two readings taken along the major slope axis, one uphill and one downhill, then averaged.
25) N	Aspect is north (338° to 67°)	Measured using a compass, readings taken along the major slope axis.
26) E	Aspect is east (68° to 157°)	Same as 25.
27) S	Aspect is south (158° to 247°)	Same as 25.
28) W	Aspect is west (248° to 337°)	Same as 25.
29) LOWTHD	Roost location occurs on lower one-third of slope	Estimated using a topographic map (scale = 1:24,000), roost site location taken with respect to nearest river or stream channel and major ridge or summit top.
30) MIDTHD	Roost location occurs on middle one-third of slope	Same as 29.
31) UPTHD	Roost location occurs on upper one-third of slope	Same as 29.
32) DISWTR (m)	Distance to free running water	Measured using a measuring tape or estimated from topographic maps (scale = 1:24,000).
33) OVRCST	Overcast sky conditions	Direct observation.
34) CLEAR	Clear sky conditions	Same as 33.
35) PCLDY	Partly cloudy sky conditions	Same as 33.
36) TROOST	Roost site temperature (°C)	Measured using a thermometer, readings taken in shade of roost tree at a height of 1.8 m (6.0 ft).
37) TAMBIEN	Ambient air temperature (°C)	Same as 36, readings taken in direct sunlight in an open vegetated area at a height of 1.8 m (6.0 ft).

Table 2. Acronyms, Descriptions, and Methods Used for Variables Describing Foraging and roosting location Vegetation Plots.

Acronym	Description	Method
Tree density and basal area by species:		
1. LWFDN	Live white fir, Abies concolor, density	All trees greater than 10.0 cm (4.0 in) in diameter at breast height (DBH) within a 0.04 ha (0.1 ac) circle were sampled as trees, those less were sampled as shrubs (after James 1971). Tree density was calculated by multiplying the number of trees within the 0.04 ha circle by 10. Snags were defined as any completely or partially dead, standing tree with a minimum DBH of 10.0 cm (4.0 in) an height of 1.8 m (6.0 ft) (Thomas 1979). Every other borderline tree or snag was considered to be in the plot. All trees or snags within the plot radius were recorded by species and placed into size classes defined by DBH intervals. Five size classes were recognized: Size Class 1, 10.0 to 12.3 cm (4.0 to 4.9 in) DBH; Size Class 2, 12.5 to 27.3 cm (5.0 to 10.9 in) DBH; Size Class 3, 27.5 to 52.5 cm (11.0 to 20.9 in) DBH; Size Class 4, 52.5 to 89.8 cm (21.0 to 35.9 in) DBH; and Size Class 5, greater than 90.0 cm (36.0 in) DBH. Diameters were measured to the nearest .3 cm (0.1 in) using a DBH tape. Trees with trunks divided below 1.36 m (4.5 ft) were considered to be two trees. Vegetation plot centers were defined by plotted radio-telemetry foraging locations or by visiting marked roost trees and selecting a point on the ground directly below an owl's observed location in the tree. A compass, topographic map (scale = 1:24,000), and an altimeter were used to locate plotted foraging locations.
2. SWFDN	Snag white fir density	Same as 1.
3. LWFBA	Live white fir basal area	Individual basal areas (ft^2/ac) were calculated basal area = .005454 x DBH^2. Total basal area was calculated by multiplying the sum basal area for all trees within the plot radius by 10.

Table 2 (continued).

	Acronym	Description	Method
4.	SWFBA	Snag white fir basal area	Same as 3.
5.	LDFDN	Live Douglas-fir, Pseudotsuga menziesii, density	Same as 1.
6.	SDFDN	Snag Douglas-fir density	Same as 1.
7.	LDFBA	Live Douglas-fir basal area	Same as 3.
8.	SDFBA	Snag Douglas-fir basal area	Same as 3.
9.	LTODN	Live tanoak, Lithocarpus densiflorus, density	Same as 1.
10.	STODN	Snag tanoak density	Same as 1.
11.	LTOBA	Live tanoak basal area	Same as 3.
12.	STOBA	Snag tanoak basal area	Same as 3.
13.	LMADDN	Live Pacific madrone, Arbutus menziesii, density	Same as 1.
14.	SMADDN	Snag Pacific madrone density	Same as 1.
15.	LMADBA	Live Pacific madrone basal area	Same as 3.
16.	SMADBA	Snag Pacific madrone	Same as 3.
17.	LCLODN	Live canyon-live oak, Quercus chrysolepis, density	Same as 1.
18.	SCLODN	Snag canyon-live oak density	Same as 1.
19.	LCLOBA	Live canyon-live oak basal area	Same as 3.
20.	SCLOBA	Snag canyon-live oak basal area	Same as 3.
21.	LBLMDN	Live big-leaf maple, Acer macrophyllum, density	Same as 1.
22.	SBLMDN	Snag big-leaf maple density	Same as 1.
23.	LBLMBA	Live big-leaf maple density	Same as 3.
24.	SBLMBA	Snag big-leaf maple density	Same as 3.
25.	LICDN	Live incense cedar, Libocedrus decurrens, density	Same as 1.
26.	SICDN	Snag incense cedar density	Same as 1.
27.	LICBA	Live incense cedar basal area	Same as 3.
28.	SICBA	Snag incense cedar basal area	Same as 3.
29.	LOWODN	Live Oregon white oak, Quercus garryana, density	Same as 1.

Table 2 (continued).

	Acronym	Description	Method
30.	SOWODN	Snag Oregon white oak density	Same as 1.
31.	LOWOBA	Live Oregon white oak basal area	Same as 3.
32.	SOWOBA	Snag Oregon white oak basal area	Same as 3.
33.	LCBODN	Live California black oak, Quercus kelloggii, density	Same as 1.
34.	SCBODN	Snag California black oak density	Same as 1.
35.	LCBOBA	Live California black oak basal area	Same as 3.
36.	SCBOBA	Snag California black oak basal area	Same as 3.
37.	LPYDN	Live Pacific yew, Taxus brevifolia, density	Same as 1.
38.	SPYDN	Snag Pacific yew density	Same as 1.
39.	LPYBA	Live Pacific yew basal area	Same as 3.
40.	SPYBA	Snag Pacific yew basal area	Same as 3.
41.	LRADN	Live red alder, Alnus rubra, density	Same as 1.
42.	SRADN	Snag red alder density	Same as 1.
43.	LRABA	Live red alder basal area	Same as 3.
44.	SRABA	Snag red alder basal area	Same as 3.
45.	LPDDN	Live mountain dogwood, Cornus nuttallii, density	Same as 1.
46.	SPDDN	Snag mountain dogwood density	Same as 1.
47.	LPDBA	Live mountain dogwood basal area	Same as 3.
48.	SPDBA	Snag mountain dogwood basal area	Same as 3.
49.	LCHDN	Live giant chinquapin, Castanopsis chrysophylla, density	Same as 1.
50.	SCHDN	Snag giant chinquapin density	Same as 1.
51.	LCHBA	Live giant chinquapin basal area	Same as 3.
52.	SCHBA	Snag giant chinquapin basal area	Same as 3.
53.	LPPDN	Live ponderosa pine, Pinus ponderosa, density	Same as 1.
54.	SPPDN	Snag ponderosa pine density.	Same as 1.
55.	LPPBA	Live ponderosa pine basal area	Same as 3.

Table 2 (continued).

Acronym	Description	Method
56. SPPBA	Snag ponderosa pine basal area	Same as 3.
57. LSPDN	Live sugar pine, Pinus lambertiana, density	Same as 1.
58. SSPDN	Snag sugar pine density	Same as 1.
59. LSPBA	Live sugar pine basal area	Same as 3.
60. SSPBA	Snag sugar pine basal area	Same as 3.
61. LJPDN	Live Jeffrey pine, Pinus jeffreyi, density	Same as 1.
62. SJPDN	Snag Jeffrey pine density	Same as 1.
63. LJPBA	Live Jeffrey pine basal area	Same as 3.
64. SJPBA	Snag Jeffrey pine basal area	Same as 3.
65. DEC1	Decadence Level 1	Three plot decadence levels were recognized, based on deterioration characteristics for Douglas-fir. Level 1 (trees dead less than one year): foliage, 10% or more present; twigs, 75% or more present; limbs, top, and bark are intact; and fresh Polyporus volvatus present. Level 2 (trees dead 1 to 5 years): foliage, less than 10% present; twigs, 10 to 75% present; some breakage in top one-quarter of tree; some bark sloughing on smaller trees; and Fomes pinicola present. Level 3 (trees dead greater than 5 years): foliage, absent; twigs, less than 10% present; most limbs falling; upper one-half of top broken on about 50% of trees; bark is sloughing; and Fomes pinicola and other conks present (U.S. Forest Service 1980).
66. DEC2	Decadence level 2	Same as 65.
67. DEC3	Decadence level 3	Same as 65.
68. CCLOS	Percent total canopy closure	Estimated using a spherical densiometer, four readings taken 4.6 m (15.0 ft) from plot center, one at each major cardinal heading, then averaged.
Ground Cover:		
69. SHRBTRE	Percent ground cover for trees less than 10.0 cm (4.0 in) DBH	Measured using a line intercept method (Muller-Dombois and Ellenberg 1974). The line intercept path, 22.7 m (75.0 ft) in length, was located within the 0.04 ha circle and oriented on a north-south axis.

Table 2 (continued).

Acronym	Description	Method
70. SHRUB	Percent shrub ground cover. (Persistent woody forms usually with several basal shoots)	Same as 69.
71. HERB	Percent herbaceous ground cover	Ten 65 cm^2 (10 in^2) quadrats were alternately placed on opposite side of the line intercept path at 1.8 m (6.0 ft) intervals. Percent total herbaceous cover was ocularly estimated to the nearest five percent.
72. LITTER	Percent litter ground cover (organic debris on the forest floor, including branches less than 2.5 cm (1.0 in) in diameter at large end, bare soil, moss, and rocks)	Same as 71.
73. DD1	Percent ground cover for fallen, dead or dying woody debris on forest floor, large end diameter 2.5 cm to 30.0 cm (1.0 in to 12.0 in)	Same as 69.
74. DD2	Percent ground cover for fallen, dead or dying, woody debris on forest floor, large end diameter greater than 30.0 cm (12.0 in)	Same as 69.
Shrub Layers:		
Layer 7		
75. SDF7	Dominant shrub species is Douglas-fir	Dominant shrub species within each 0.04 ha circle were recorded for shrub layers arbitrarily defined by 1.0 m (3.3 ft) height intervals. Seven shrub layers were recognized: layer 1, 0.0 to 1.0 m (0.0 to 3.3 ft); layer 2, 1.0 to 2.0 m (3.3 to 6.6 ft); layer 3, 2.0 to 3.0 m (6.6 to 9.9 ft); layer 4, 3.0 to 4.0 m (9.9 to 13.2 ft); layer 5, 4.0 to 5.0 m (13.2 to 16.5 ft); layer 6, 5.0 to 6.0 m (16.5 to 19.8 ft); and layer 7, 6.0 to 7.0 m (19.8 to 23.1 ft). Shrub heights were measured using a clinometer or Relaskop. A subjective estimate was made of the dominant shrub species in each layer and the total number of layers in each plot.
76. S107	Dominant shrub species is tanoak	Same as 75.
77. SCL07	Dominant shrub species is canyon-live oak	Same as 75.
78. SRA7	Dominant shrub species is red alder	Same as 75.
Layer 6		
79. SDF6	Dominant shrub species is Douglas-fir	Same as 75.
80. ST06	Dominant shrub species is tanoak	Same as 75.

Table 2 (continued).

	Acronym	Description	Method
81.	SRA6	Dominant shrub species is red alder	Same as 75.
Layer 5			
82.	SDF5	Dominant shrub species is Douglas-fir	Same as 75.
83.	ST05	Dominant shrub species is tanoak	Same as 75.
84.	SCL05	Dominant shrub species is canyon live-oak	Same as 75.
85.	SRA5	Dominant shrub species is red alder	Same as 75.
Layer 4			
86.	SDF4	Dominant shrub species is Douglas-fir	Same as 75.
87.	ST04	Dominant shrub species is tanoak	Same as 75.
88.	SCL04	Dominant shrub species is canyon live-oak	Same as 75.
89.	SBLM4	Dominant shrub species is big-leaf maple	Same as 75.
90.	SRA4	Dominant shrub species is red alder	Same as 75.
Layer 3			
91.	SDF3	Dominant shrub species is Douglas-fir	Same as 75.
92.	ST03	Dominant shrub species is tanoak	Same as 75.
93.	SCL03	Dominant shrub species is canyon live-oak	Same as 75.
94.	SIC3	Dominant shrub species is incense cedar	Same as 75.
95.	SHZL3	Dominant shrub species is California hazel, Corylus cornuta	Same as 75.
96.	SCEAN3	Dominant shrub species is buckbrush, Ceanothus cuneatus	Same as 75.
97.	SPOAK3	Dominant shrub species is poison oak, Rhus diversiloba	Same as 75.
Layer 2			
98.	SDF2	Dominant shrub species is Douglas-fir	Same as 75.
99.	ST02	Dominant shrub species is tanoak	Same as 75.
100.	SCL02	Dominant shrub species is canyon live-oak	Same as 75.
101.	SIC2	Dominant shrub species is incense cedar	Same as 75.
102.	SHZL2	Dominant shrub species is California hazel	Same as 75.

Table 2 (continued).

Acronym	Description	Method
103. SCEAN2	Dominant shrub species is buckbrush	Same as 75.
104. SPOAK2	Dominant shrub species is poison oak	Same as 75.
Layer 1		
105. SDF1	Dominant shrub species is Douglas-fir	Same as 75.
106. ST01	Dominant shrub species is tanoak	Same as 75.
107. SCL01	Dominant shrub species is canyon live-oak	Same as 75.
108. SROSE1	Dominant shrub species is wood rose, Rosa gymnocarpa	Same as 75.
109. SHZL1	Dominant shrub species is California hazel	Same as 75.
110. SPOAK1	Dominant shrub species is poison oak	Same as 75.
111. SFERN1	Dominant shrub species is sword fern, Polystichum munitum	Same as 75.
112. SSALAL1	Dominant shrub species is salal, Gaultheria shallon	Same as 75.
113. SCEAN1	Dominant shrub species is buckbrush	Same as 75.
114. SOGRP1	Dominant shrub species is Oregon grape, Berberis nervosa	Same as 75.
Tree density by size class:		
Size class 1		
115. LDN1	Live tree density	Same as 1.
116. SDN1	Snag tree density	Same as 1.
Size class 2		
117. LDN2	Live tree density	Same as 1.
118. SDN2	Snag tree density	Same as 1.
Size class 3		
119. LDN3	Live tree density	Same as 1.
120. SDN3	Snag tree density	Same as 1.
Size class 4		
121. LDN4	Live tree density	Same as 1.
122. LDN4	Snag tree density	Same as 1.

Table 2 (continued).

Acronym	Description	Method
Size class 5		
123. LDN5	Live tree density	Same as 1.
124. SDN5	Snag tree density	Same as 1.
Tree basal area by size class:		
Size class 1		
125. LBA1	Live tree basal area	Same as 3.
126. SBA	Snag tree basal area	Same as 3.
Size class 2		
127. LBA2	Live tree basal area	Same as 3.
128. SBA2	Snag tree basal area	Same as 3.
Size class 3		
129. LBA3	Live tree basal area	Same as 3.
130. SBA3	Snag tree basal area	Same as 3.
Size class 4		
131. LBA4	Live tree basal area	Same as 3.
132. SBA4	Snag tree basal area	Same as 3.
Size class 5		
133. LBA5	Live tree basal area	Same as 3.
134. SBA5	Snag tree basal area	Same as 3.
Total hardwood or conifer live tree density and basal area by size class:		
Size Class 1		
135. HDN1	Hardwood density	Same as 1.
136. HBA1	Hardwood basal area	Same as 3.
137. CDN1	Conifer density	Same as 1.
138. CBA1	Conifer basal area	Same as 3.
Size Class 2		
139. HDN2	Hardwood density	Same as 1.
140. HBA2	Hardwood basal area	Same as 3.

Table 2 (continued).

Acronym	Description	Method
141. CDN2	Conifer density	Same as 1.
142. CBA2	Conifer basal area	Same as 3.
Size Class 3		
143. HDN3	Hardwood density	Same as 1.
144. HBA3	Hardwood basal area	Same as 3.
145. CDN3	Conifer density	Same as 1.
146. CBA3	Conifer basal area	Same as 3.
Size Class 4		
147. HDN4	Hardwood density	Same as 1.
148. HBA4	Hardwood basal area	Same as 3.
149. CDN4	Conifer density	Same as 1.
150. CBA4	Conifer basal area	Same as 3.
Size Class 5		
151. HDN5	Hardwood density	Same as 1.
152. HBA5	Hardwood basal area	Same as 3.
153. CDN5	Conifer density	Same as 1.
154. CBA5	Conifer basal area	Same as 3.
Physiography:		
Aspect		
155. N	Aspect is north (338° to 67°)	Measured from plot center using a compass.
156. E	Aspect is east (68° to 157°)	Measured from plot center using a compass.
157. S	Aspect is south (158° to 247°)	Measured from plot center using a compass.
158. W	Aspect is west (248° to 337°)	Measured from plot center using a compass.
Elevation		
159. ELEV	Elevation	Measured from plot center using an altimeter.
Total tree density, or basal area:		
160. TLDN	Total live tree density, all sizes classes combined	Same as 1.

Table 2 (continued).

Acronym	Description	Method
161. TSDN	Total snag tree density, all sizes classes combined	Same as 1.
162. TDN1	Size Class 1, total density (live and snag tree combined)	Same as 1.
163. TDN2	Size Class 2, total density (live and snag tree combined)	Same as 1.
164. TDN3	Size Class 3, total density (live and snag tree combined)	Same as 1.
165. TDN4	Size Class 4, total density (live and snag tree combined)	Same as 1.
166. TDN5	Size Class 5, total density (live and snag tree combined)	Same as 1.
167. TBA1	Size Class 1, total basal area (live and snag tree combined)	Same as 3.
168. TBA2	Size Class 2, total basal area (live and snag tree combined)	Same as 3.
169. TBA3	Size Class 3, total basal area (live and snag tree combined)	Same as 3.
170. TBA4	Size Class 4, total basal area (live and snag tree combined)	Same as 3.
171. TBA5	Size Class 5, total basal area (live and snag tree combined)	Same as 3.
172. TDN	Total density, live and snag tree for all size classes combined	Same as 1.
173. TBA	Total basal area live and snag tree for all size classes combined	Same as 3.
174. THDN	Total hardwood live tree density, all size classes combined	Same as 1.
175. THBA	Total hardwood live tree basal area, all size classes combined	Same as 3.
176. TCDN	Total conifer live tree density, all size classes combined	Same as 1.
177. TCBA	Total conifer live tree basal area, all size classes combined	Same as 3.

Table 2 (continued).

Acronym	Description	Method
Snags:		
Species		
178. DF	Snag species is Douglas-fir	See (1) for snag definition.
179. TO	Snag species is tanoak	"
180. MAD	Snag species is Pacific madrone	"
181. CLO	Snag species is canyon live-oak	"
182. BLM	Snag species is big-leaf maple	"
183. IC	Snag species is incense cedar	"
184. OWO	Snag species is Oregon white oak	"
185. CBO	Snag species is California black oak	"
186. PY	Snag species is Pacific yew	"
187. SP	Snag species is sugar pine	"
188. JP	Snag species is Jeffrey pine	"
189. PP	Snag species is ponderosa pine	"
190. WF	Snag species is white fir	"
191. CHIN	Snag species is chinquapin	"
192. DECLIN	Declining snag stage	Snags (see 1) were further placed into successional stages (after Thomas 1979). Snag stages were identified by decay condition, and the amount of bark, trunk, and foliage present snags. Hard and soft decay conditions described by Thomas (1979) were recognized. Five snag successional stages were recognized: declining stage, usually in a hard decay condition with most of the bark and top intact and some green foliage present; dead stage, lacking green foliage and usually in hard decay condition with most bark, twigs, and branches with twigs present; clean stage, in hard or soft decay condition with most bark absent, green foliage lacking, some branches present, and the trunk broken or intact; broken stage, in hard or soft decay condition with loose or intact bark, at least one-quarter of the trunk broken, no green foliage, and most branches absent; and decomposed stage, usually in soft decay condition with intact or loose bark, most of trunk missing, and few or no branches.

Table 2 (continued).

Acronym	Description	Method
193. DEAD	Dead snag stage	Same as 192.
194. CLEAN	Clean snag stage	Same as 192.
195. BROKEN	Broken snag stage	Same as 192.
196. DECOMP	Decomposed snag stage	Same as 192.
Decay condition		
197. HARD	Hard decay condition	Same as 192.
198. SOFT	Soft decay condition	Same as 192.
Bark characteristics		
199. INTACT	Bark is intact	Visual identification.
200. LOOSE	Bark is loose and patchy	Visual identification.
201. CLEAN	Bark is absent	Visual identification.
Broken trunk characteristics		
202. UONE	Upper one-quarter of trunk is broken	Visual identification.
203. UTWO	Upper one-half of trunk is broken	Visual identification.
204. UTHREE	Upper three-quarters of trunk is broken	Visual identification.
205. TNB	Trunk not broken	Visual identification.
Foliage characteristics		
206. FPARTL	Green foliage partially present	Visual identification.
207. FABSENT	Green foliage absent	Visual identification.
Statistics		
208. DBH	Diameter at breast height	Measured to the nearest 0.3 cm (0.1 in) using a DBH tape.
209. HT	Height (ft)	Measured using a Relaskop or clinometer.
210. BA	Basal area (ft^2/ac)	Basal area = .005454 x DBH^2.
211-215 CDBH 1-5	Conifer DBH by size class	See 1 for size class definitions. See 208 for DBH method.
216-220 CHT 1-5	Conifer height by size class	See 1 of size class definitions. See 209 for height method. Three trees were averaged for each size class.

Table 2 (continued).

Acronym	Description	Method
221-225 HDBH1-5	Hardwood DBH by size class	Same as 211-215.
226-230 HHT1-5	Hardwood height by size class	Same as 216-220.

Appendix D. Habitat Selection.

Table 1. Habitat Selection by 7 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 to 24 August 1981.[1/]

Owl[2/]	Habitat type[3/]	Total area(ac)	Propor. of total area	Observed use in habitat type	Expected use in habitat type	Chi-square value	Propor. of observed use in habitat type	Confidence interval on propor. of observed use	Habitat selection[4/]
Pancho:									
	seral stage 3	286	.586	24	57	19.105	.247	.160<p<.334	less
	seral stage 4	202	.414	73	40	27.225	.753	.691<p<.815	greater
		488	1.000	97	97	46.335	1.000		
	seral stage 2	193	0						
Lucia:									
	seral stage 3	662	.824	42	120	50.700	.288	.220<p<.356	less
	seral stage 4	141	.176	104	26	234.000	.712	.688<p<.756	greater
		803	1.000	146	146	284.700	1.000		
	seral stage 2	157		0					
Harvey:									
	seral stage 3	53	.185	6	16	6.250	.069	.000<p<.171	less
	seral stage 4	234	.815	81	71	1.408	.931	.893<p<.961	greater
		287	1.000	87	87	7.658	1.000		
	seral stage 2	188		0					
Bubba:									
	seral stage 4	345		46			0		
				46			1.000	1.000	greater
	seral stage 3	153		0					
	seral stage 2	102		0					
Suave:									
	seral stage 3	280	.335	1	17	15.058	.020	.000<p< .158	less
	seral stage 4	556	.665	49	33	7.758	.980	.955<p<1.005	greater
		836	1.000			22.816	1.000		
	seral stage 2	565		6					
Mayo:									
	seral stage 3	194	.331	17	29	4.966	.195	.104<p<.286	less
	seral stage 4	392	.669	70	57	2.483	.805	.758<p<.852	greater
		586	1.000	87	87	7.449	1.000		
	seral stage 2	178		1					
Catalina:									
	seral stage 3	405	.317	13	21	3.048	.194	.086<p<.302	less
	seral stage 4	873	.683	54	46	1.391	.806	.753<p<.859	greater
		1278	1.000	67	67	4.439	1.000		
	seral stage 2	397		2					

1/ Foraging (n = 378) and roosting (n = 238) data were pooled for each owl because heterogeneity chi-square analyses indicated that the distribution of each owl's foraging and roosting location were the same for each habitat type. Analyses were only based on locations within seral stages 3 and 4 because of the low number (n=9) of occurrences within seral stage 2. The inclusion of seral stage 2 would have violated assumptions of chi-square and habitat selection techniques (Cochran 1954; Neu et al. 1974; Zar 1974).

2/ Owls are: Pancho = adult male; Lucia = adult female; Harvey = adult male; Bubba = adult male; Suave = immature female; Mayo = adult male; Catalina = adult female. See Tables 2, 3, and 4.

3/ Habitat types are: seral stage 2 = brush/seedling/sapling tree stand; seral stage 3 = pole/medium tree stand; seral stage 4 = mature/old-growth tree stand (Marcot 1979). Seral stage 2 presented for comparison but not used in the analysis.

4/ Habitat use was significantly less (less) or greater (greater) than expected, based on its availability (P<.05).

Table 1. Habitat Characteristics for 10 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 - 24 August 1981. Results are based on .1 ac (.04 ha), circular plots (n = 496). All habitat areas are combined.[1/]

Canopy characteristics:

Interval[2]	Composition (basis = basal area)	stems/acre			Basal area (ft^2/ac)			Diameter at breast height (DBH; in)[3]				Height (ft)[3]			
		$\bar{x}$	± S.E.	Range	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range
DBH (4.0-4.9 in):															
Conifer	21.0	6.3	.6	0-90	.714	.070	0- 18.390	111	4.4	.1	4.0- 4.9	111	30.4	.9	15-79
Hardwood	65.4	19.5	1.1	0-250	2.221	.139	0- 30.690	277	4.5	.1	4.0- 4.9	277	25.6	.4	7-44
Snag	13.6	4.6	.5	0-120	.463	.049	0- 7.460	183	4.4	.1	4.0- 4.9	183	22.7	.8	6-66
Total	100.0	30.4	1.4	0-310	3.398	.146	0- 31.650	-	-	-	-	-	-	-	-
DBH (5.0-10.9 in):															
Conifer	29.2	28.1	1.6	0-150	9.353	.570	0- 64.240	169	7.5	.1	5.3-10.7	169	50.7	1.0	20-94
Hardwood	60.7	63.8	3.1	0-470	19.465	.978	0- 153.360	298	7.2	.1	5.1-10.4	298	40.7	.7	6-82
Snag	10.1	11.2	.8	0-140	3.252	.262	0- 39.060	502	7.0	.7	5.0-10.9	502	27.9	.7	6-91
Total	100.0	103.1	3.2	0-470	32.070	1.054	0- 166.790	-	-	-	-	-	-	-	-
DBH (11.0-20.9 in):															
Conifer	46.2	19.6	1.3	0-160	24.729	1.632	0- 202.600	210	14.8	.2	11.0-20.8	210	91.1	1.5	35-170
Hardwood	44.7	19.9	1.1	0-150	24.067	1.357	0- 244.100	226	14.8	.2	11.0-20.9	226	64.5	1.1	29-127
Snag	8.9	3.7	.4	0-60	4.732	.532	0- 106.390	155	14.7	.2	11.0-20.9	155	35.9	2.7	6-152
Total	100.0	43.2	1.5	0-200	53.528	2.037	0- 271.900	-	-	-	-	-	-	-	-
DBH (21.0-35.9 in):															
Conifer	66.7	10.9	.6	0-90	45.094	2.743	0- 322.250	240	27.1	.2	21.1-35.9	240	134.3	2.0	25-241
Hardwood	21.7	4.1	.4	0-50	14.651	1.317	0- 178.760	86	25.7	.4	21.0-35.9	86	81.2	2.2	35-127
Snag	11.6	2.0	.2	0-30	7.859	.967	0- 162.760	89	27.4	.5	21.1-35.9	89	58.1	5.9	6-208
Total	100.0	17.0	.7	0-90	67.604	2.974	0- 322.250	-	-	-	-	-	-	-	-
DBH (>36.0 in):															
Conifer	86.7	11.9	.6	0-60	166.857	8.632	0- 963.310	295	50.6	.6	36.2-90.8	295	175.3	1.6	73-259
Hardwood	3.0	.6	.1	0-20	5.793	1.304	0- 410.380	7	42.1	3.2	36.1-60.8	7	79.4	7.0	48-104
Snag	10.3	1.6	.2	0-30	19.850	2.634	0- 410.230	62	48.3	1.3	36.0-79.0	62	80.4	7.9	6-192
Total	100.0	14.1	.6	0-60	192.500	8.922	0-1011.600	-	-	-	-	-	-	-	-
Subtotal (all DBH intervals):															
Conifer	70.7	76.8	3.0	0-390	246.747	8.800	0-1013.190	-	-	-	-	-	-	-	-
Hardwood	19.0	107.9	4.3	0-640	66.197	2.800	0- 462.740	-	-	-	-	-	-	-	-
Snag	10.3	23.1	1.4	0-260	36.156	3.100	0- 483.480	-	-	-	-	-	-	-	-
Total (all DBH intervals):	100.0	207.8	4.7	0-670	349.100	8.700	0-1092.800	-	-	-	-	-	-	-	-

Table 1 (Continued).

	$\bar{x}$	± S.E.	Range
Percent ground cover:			
Trees less than 4 in DBH	35.1	1.1	0-99.9
Shrub	8.1	.6	0-82.8
Herb	7.7	.7	0-98.2
Litter (diameter = < 1 in)	92.0	.6	0-99.9
Logs			
diameter = 1 to 12 in	6.1	.4	0-97.0
diameter = > 12 in	2.1	.2	0-50.4
Percent canopy closure:			
Percent total canopy closure	86.9	.8	0-99.0
Elevation (ft):	3174.6	26.6	1700-4590

	n	% Frequency of occurrence
Decadence ratings:		
Level 1 (tree dead < 1 year)	133	26.8
Level 2 (tree dead 1-5 years)	123	24.8
Level 3 (tree dead > 5 years)	240	48.4
Total:	496	100.0
Aspect:		
North	245	49.4
East	144	29.0
South	62	12.5
West	45	9.1
Total:	496	100.0

1/ Habitat areas are: core area (n = 398), an aggregation of timber stand polygons which accounted for greater than 55% of an owl's total number of foraging locations; non-core area (n = 48), area exclusive of core area; roost (n = 50), verified roost locations.

2/ For each interval: Conifer = live conifer trees; Hardwood = live hardwood trees; Snag = conifer and hardwood snag trees combined; Total = conifer, hardwood, and snag trees combined.

3/ Mean ($\bar{x}$) represents the mean of means.

4/ Shrub layers are: Layer 1, 0-3.3 ft.; Layer 2, 3.3-6.6 ft.; Layer 3, 6.6-9.9 ft.; Layer 4, 9.9-13.2 ft.; Layer 5, 13.2-16.5 ft.; Layer 6, 16.5-19.8 ft.; Layer 7, 19.8-23.1 ft.

Table 2 (continued).

Shrub layer characteristics:
(percent frequency of occurrence)

Shrub species	Shrub layer[4] 1		2		3		4		5		6		7	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Douglas fir, *Pseudotsuga menziesii*													1	2.0
tanoak, *Lithocarpus densiflorus*	12	24.0	1	2.0	12	24.0	14	28.0	6	12.0	9	18.0	6	12.0
canyon-liveoak, *Quercus chrysolepis*	4	8.0	23	46.0	2	4.0	3	6.0	1	2.0			3	6.0
red alder *Alnus rubra*			4	8.0										
big-leaf maple, *Acer macrophyllum*							1	2.0						
incense cedar, *Taxus brevifolia*			1	2.0										
California hazel, *Corylus cornuta*	1	2.0												
buckbrush, *Ceanothus cuneatus*														
poison oak, *Rhus diversiloba*	2	4.0												
sword fern *Polystichum munitum*	6	12.0												
salal, *Gaultheria shallon*	1	2.0												
Oregon grape, *Berberis nervosa*	1	2.0												
Layer not present	23	46.0	21	42.0	36	72.0	32	64.0	43	86.0	41	82.0	40	80.0
Total:	50	100.0	50	100.0	50	100.0	50	100.0	50	100.0	50	100.0	50	100.0

Table 3. Core Area Habitat Characteristics for 10 Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 - 24 August 1981.[1] Results are based on .1 ac (.04 ha), circular plots (n = 398).

Canopy characteristics:

Interval[2]	% Composition (basis = basal area)	Stems/acre			Basal area (ft^2/ac)			Diameter at breast height (DBH; in)[3]				Height (ft)[3]			
		$\bar{x}$	± S.E.	Range	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range
DBH (4.0-4.9 in):															
Conifer	21.3	6.6	.6	0-90	.733	.069	0- 9.440	92	4.5	.1	4.0-4.9	92	30.9	1.0	15-79
Hardwood	63.6	19.0	1.3	0-250	2.183	.155	0- 30.690	216	4.5	.1	4.0-4.9	216	25.7	.5	7-44
Snag	15.1	4.9	.5	0-80	.519	.059	0- 7.460	-	-	-	-	-	-	-	-
Total	100.0	30.5	1.6	0-310	3.435	.164	0- 31.650	-	-	-	-	-	-	-	-
DBH (5.0-10.9 in):															
Conifer	30.6	29.7	1.9	0-160	9.903	.653	0- 64.240	146	7.5	.1	5.3-10.7	146	50.8	1.1	20-94
Hardwood	59.2	62.6	3.5	0-470	19.134	1.126	0- 153.360	232	7.2	.1	5.1-10.2	232	41.0	.7	6-82
Snag	10.2	11.7	1.0	0-140	3.311	.301	0- 39.060	-	-	-	-	-	-	-	-
Total	100.0	104.0	3.7	0-470	32.348	1.211	0- 166.790	-	-	-	-	-	-	-	-
DBH (11.0-20.9 in):															
Conifer	48.0	21.2	1.5	0-160	26.612	1.902	0- 202.600	176	14.7	.2	11.0-20.7	176	91.4	1.5	38-166
Hardwood	43.2	20.0	1.2	0-150	23.921	1.525	0- 244.100	174	14.6	.2	11.2-20.9	174	64.3	1.2	29-127
Snag	8.8	3.9	.4	0-60	4.897	.585	0- 104.870	-	-	-	-	-	-	-	-
Total	100.0	45.1	1.8	0-200	55.430	2.325	0- 271.900	-	-	-	-	-	-	-	-
DBH (21.0-35.9 in):															
Conifer	67.4	11.1	.7	0-60	45.310	3.018	0- 286.440	191	27.1	.3	21.1-35.6	191	135.7	2.2	54-241
Hardwood	21.6	4.2	.4	0-50	14.531	1.399	0- 155.160	68	25.6	.5	21.0-35.9	68	80.6	2.5	35-127
Snag	11.0	1.9	.3	0-30	7.396	1.054	0- 162.760	-	-	-	-	-	-	-	-
Total	100.0	17.2	.8	0-60	67.237	3.291	0- 286.440	-	-	-	-	-	-	-	-
DBH (>36.0 in):															
Conifer	87.1	11.7	.6	0-60	170.021	9.855	0- 963.310	236	51.1	.7	36.2-79.0	236	175.4	1.8	73-259
Hardwood	3.5	.7	.1	0-20	6.807	1.595	0- 410.380	6	42.1	3.8	36.1-60.8	6	75.3	6.8	48-98
Snag	9.4	1.3	.2	0-20	18.399	2.858	0- 410.230	-	-	-	-	-	-	-	-
Total	100.0	13.7	.7	0-60	195.227	10.189	0-1011.600	-	-	-	-	-	-	-	-
Subtotal (all DBH intervals):															
Conifer	71.4	80.3	3.4	0-390	252.579	9.997	0-1013.190	-	-	-	-	-	-	-	-
Hardwood	18.8	106.5	4.9	0-640	66.576	3.181	0- 462.740	-	-	-	-	-	-	-	-
Snag	9.8	23.7	1.7	0-260	34.522	3.334	0- 410.230	-	-	-	-	-	-	-	-
Total (all DBH intervals):	100.0	210.5	5.2	0-670	353.677	9.844	0-1092.300	-	-	-	-	-	-	-	-

Table 3 (continued).

	$\bar{x}$	$\bar{x}$ + S.E.	Range
Percent ground cover:			
Trees less than 4 in DBH	34.9	1.4	0-99.9
Shrub	7.3	.6	0-82.8
Herb	7.5	.7	0-98.2
Litter (diameter = < 1 in)	91.6	.7	0-99.9
Logs			
diameter = 1 to 12 in	6.2	.4	0-82.2
diameter = > 12 in	1.9	.2	0-50.4
Percent canopy closure:			
Percent total canopy closure	87.8	.8	0-99.0
Elevation (ft):	3239.4	29.8	1700-4590

	n	% Frequency of occurrence
Decadence ratings:		
Level 1 (tree dead < 1 year)	105	26.4
Level 2 (tree dead 1-5 years)	100	25.1
Level 3 (tree dead > 5 years)	193	48.5
Total:	398	100.0
Aspect:		
North	202	50.8
East	122	30.7
South	37	9.3
West	37	9.3
Total:	398	100.0

1/ Core areas were an aggregation of timber stand polygons which accounted for greater than 55% of an owl's total number of foraging locations.

2/ For each interval: Conifer = live, conifer trees; Hardwood = live, hardwood trees; Snag = conifer and hardwood, snag trees combined; Total = conifer, hardwood, and snag trees combined.

3/ Mean ($\bar{x}$) represents the mean of means.

4/ Shrub layers are: Layer 1, 0-3.3 ft.; Layer 2, 3.3-6.6 ft.; Layer 3, 6.6-9.9 ft.; Layer 4, 9.9-13.2 ft.; Layer 5, 13.2-16.5 ft.; Layer 6, 16.5-19.8 ft.; Layer 7, 19.8-23.1 ft.

Table 4 (continued).

Shrub layer characteristics:
(percent frequency of occurrence)

Shrub species	Shrub layer[4] 1 n	1 %	2 n	2 %	3 n	3 %	4 n	4 %	5 n	5 %	6 n	6 %	7 n	7 %
Douglas-fir, *Pseudotsuga menziesii*	1	2.1	2	4.2	1	2.1	3	6.2			6	12.5	4	8.3
tanoak, *Lithocarpus densiflorus*	8	16.7	11	22.9	5	10.4	8	16.7	4	8.3	3	6.2	4	8.3
canyon-liveoak, *Quercus chrysolepis*	2	4.2	2	4.2	2	4.2	2	4.2					1	2.1
red alder *Alnus rubra*													1	2.1
big-leaf maple, *Acer macrophyllum*							2	4.2						
incense cedar, *Taxus brevifolia*			2	4.2	1	2.1								
California hazel, *Corylus cornuta*	1	2.1	1	2.1	3	6.3								
buckbrush, *Ceanothus cuneatus*														
poison oak, *Rhus diversiloba*	6	12.5												
sword fern *Polystichum munitum*	5	10.4												
salal, *Gaultheria shallon*	2	4.2												
Oregon grape, *Berberis nervosa*	1	2.1												
Layer not present	22	45.9	30	62.4	36	74.9	33	68.7	44	91.7	39	81.3	83	79.2
Total:	48	100.0	48	100.0	48	100.0	48	100.0	48	100.0	48	100.0	48	100

Table 5. Habitat Characteristics for 6 male Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 - 24 August 1981.[1/] Results are based on .1 ac (.04 ha), circular plots (n = 248). All habitat areas are combined.[1/]

Canopy characteristics:

Interval[2]	% Composition (basis = basal area)	stems/acre			Basal area (ft^2/ac)			Diameter at breast height (DBH; in)[3]				Height (ft)[3]			
		$\bar{x}$	± S.E.	Range	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range
DBH (4.0-4.9 in):															
Conifer	21.0	6.6	.8	0-90	.755	.110	0- 18.390	56	4.5	.1	4.0-4.9	56	29.3	1.5	15-79
Hardwood	65.5	20.2	1.8	0-250	2.358	.228	0- 30.690	143	4.5	.1	4.0-4.9	143	25.2	.6	7-44
Snag	13.5	5.1	.9	0-120	.487	.076	0- 7.460	-	-	-	-	-	-	-	-
Total	100.0	31.9	2.3	0-310	3.600	.235	0- 31.650	-	-	-	-	-	-	-	-
DBH (5.0-10.9 in):															
Conifer	28.4	28.2	2.4	0-160	9.371	.828	0- 54.190	82	7.6	.1	5.3-10.7	82	48.1	1.4	20-80
Hardwood	61.1	64.4	4.6	0-400	20.175	1.470	0- 150.870	150	7.3	.1	5.1-10.4	150	40.2	1.0	16-72
Snag	10.5	12.1	1.3	0-140	3.473	.391	0- 39.060	-	-	-	-	-	-	-	-
Total	100.0	104.7	5.1	0-470	33.019	1.660	0- 166.790	-	-	-	-	-	-	-	-
DBH (11.0-20.9 in):															
Conifer	42.4	20.0	1.8	0-160	25.048	2.199	0- 189.780	98	14.9	.2	11.1-20.7	98	89.2	2.3	36-166
Hardwood	47.7	22.6	1.7	0-150	28.216	2.248	0- 244.100	117	14.9	.2	11.0-19.9	117	60.4	1.4	29-113
Snag	9.9	4.3	.6	0-60	5.842	.896	0- 106.390	-	-	-	-	-	-	-	-
Total	100.0	46.9	2.3	0-180	59.106	2.976	0- 271.900	-	-	-	-	-	-	-	-
DBH (21.0-35.9 in):															
Conifer	65.4	11.9	1.0	0-80	48.773	4.207	0- 322.250	129	26.9	.3	21.1-35.9	129	129.5	2.5	25-182
Hardwood	21.7	4.8	.6	0-50	16.173	1.883	0- 155.160	45	25.1	.5	21.6-35.9	45	79.8	2.9	36-127
Snag	12.9	2.4	.4	0-30	9.658	1.592	0- 162.760	-	-	-	-	-	-	-	-
Total	100.0	19.1	1.0	0-80	74.604	4.397	0- 322.250	-	-	-	-	-	-	-	-
DBH (>36.0 in):															
Conifer	81.5	9.6	.7	0-60	134.498	11.758	0- 963.310	129	49.5	1.0	36.3-90.8	129	170.1	2.7	73-259
Hardwood	4.0	.7	.2	0-20	6.655	1.706	0- 201.610	6	43.1	3.6	36.8-60.8	6	80.3	8.3	48-104
Snag	14.5	1.8	.3	0-30	23.828	4.232	0- 410.230	-	-	-	-	-	-	-	-
Total	100.0	12.1	.8	0-60	164.981	12.063	0-1011.600	-	-	-	-	-	-	-	-
Subtotal (all DBH intervals):															
Conifer	65.1	76.3	4.4	0-310	218.445	12.557	0-1013.190	-	-	-	-	-	-	-	-
Hardwood	21.9	112.7	6.4	0-520	73.577	4.298	0- 340.830	-	-	-	-	-	-	-	-
Snag	13.0	25.7	2.1	0-200	43.288	5.208	0- 483.480	-	-	-	-	-	-	-	-
Total (all DBH intervals):	100.0	214.7	7.1	0-610	335.310	12.2	0-1092.800	-	-	-	-	-	-	-	-

Table 5 (continued).

	$\bar{x}$	$\bar{x}$ + S.E.	Range
Percent ground cover:			
Trees less than 4 in DBH	32.9	1.7	0-99.9
Shrub	9.4	1.0	0-81.5
Herb	8.8	1.0	0-98.2
Litter (diameter = < 1 in)	93.0	.8	2.2-99.9
Logs			
diameter = 1 to 12 in	4.9	.4	0-73.3
diameter = > 12 in	2.2	.3	0-27.1
Percent canopy closure:			
Percent total canopy closure	86.2	1.2	0-98.0
Elevation (ft):	3249.2	39.6	1700-4590

	n	% Frequency of occurrence
Decadence ratings:		
Level 1 (tree dead < 1 year)	85	34.3
Level 2 (tree dead 1-5 years)	62	25.0
Level 3 (tree dead > 5 years)	101	40.7
Total:	248	100.0
Aspect:		
North	121	48.8
East	77	31.0
South	25	10.1
West	25	10.1
Total:	248	100.0

1/ Habitat areas are: core area (n = 131) - an aggregation of timber stand polygons which accounted for greater than 55% of an owl's total number of foraging locations; non-core (n = 30) - area exclusive of core area; roost (n = 27) - verified roost locations.

2/ For each interval: Conifer = live, conifer trees; Hardwood = live, hardwood trees; Snag = conifer and hardwood, snag trees combined; Total = conifer, hardwood, and snag trees combined.

3/ Mean ($\bar{x}$) represents the mean of means.

4/ Shrub layers are: Layer 1, 0-3.3 ft.; Layer 2, 3.3-6.6 ft.; Layer 3, 6.6-9.9 ft.; Layer 4, 9.9-13.2 ft.; Layer 5, 13.2-16.5 ft.; Layer 6, 16.5-19.8 ft.; Layer 7, 19.8-23.1 ft.

Table 6 (continued).

Shrub layer characteristics:
(percent frequency of occurrence)

Shrub species	Shrub layer[4] 1 n	1 %	2 n	2 %	3 n	3 %	4 n	4 %	5 n	5 %	6 n	6 %	7 n	7 %
Douglas fir, *Pseudotsuga menziesii*			1	3.7									1	3.7
tanoak, *Lithocarpus densiflorus*	6	22.2	13	48.1	7	25.9	8	29.6	3	11.1	5	18.5	5	18.5
canyon-liveoak, *Quercus chrysolepis*	1	3.7	1	3.7	2	7.4			1	3.7				
red alder *Alnus rubra*														
big-leaf maple, *Acer macrophyllum*							1	3.7						
incense cedar, *Taxus brevifolia*			1	3.7										
California hazel, *Corylus cornuta*														
buckbrush, *Ceanothus cuneatus*														
poison oak, *Rhus diversiloba*	2	7.4												
sword fern *Polystichum munitum*	5	18.5												
salal, *Gaultheria shallon*	1	3.7												
Oregon grape, *Berberis nervosa*	1	3.7												
Layer not present	11	40.7	11	40.7	18	66.7	18	66.7	23	85.2	22	81.5	21	77.8
Total:	27	100.0	27	100.0	27	100.0	27	100.0	27	100.0	27	100.0	21	100.0

Table 7. Core Area Habitat Characteristics for 6 Male Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 - 24 August 1981. Results are based on .1 ac (.04 ha), circular plots (n = 191).

Canopy characteristics:

Interval [2]	% Composition (basis = basal area)	stems/acre $\bar{x}$	stems/acre ± S.E.	stems/acre Range	Basal area (ft^2/ac) $\bar{x}$	Basal area (ft^2/ac) ± S.E.	Basal area (ft^2/ac) Range	Diameter at breast height (DBH; in) [3] n	DBH $\bar{x}$	DBH ± S.E.	DBH Range	Height (ft) [3] n	Height $\bar{x}$	Height ± S.E.	Height Range
DBH (4.0-4.9 in):															
Conifer	19.7	6.6	.9	0-90	.710	.096	0- 9.440	45	4.5	.1	4.0-4.9	45	30.7	1.7	15-79
Hardwood	64.6	19.5	2.0	0-250	2.324	.268	0- 30.690	105	4.5	.1	4.0-4.9	105	24.9	.6	7-44
Snag	15.7	5.5	.9	0-80	.565	.095	0- 7.460	-	-	-	-	-	-	-	-
Total	100.0	31.6	2.6	0-310	3.599	.273	0- 31.650	-	-	-	-	-	-	-	-
DBH (5.0-10.9 in):															
Conifer	30.4	30.6	2.8	0-160	10.277	.992	0- 54.190	71	7.6	.1	5.3-10.7	71	48.5	1.5	20-80
Hardwood	58.4	63.3	5.5	0-400	19.774	1.776	0- 150.870	110	7.2	.1	5.1-10.2	110	39.7	1.0	16-67.3
Snag	11.2	13.5	1.7	0-140	3.808	.485	0- 39.060	-	-	-	-	-	-	-	-
Total	100.0	107.4	6.1	0-470	33.859	2.024	0- 166.790	-	-	-	-	-	-	-	-
DBH (11.0-20.9 in):															
Conifer	45.0	22.6	2.2	0-160	27.921	2.672	0- 189.760	81	14.8	.2	11.1-20.7	81	88.3	2.3	38-166
Hardwood	45.3	22.9	2.0	0-150	28.142	2.612	0- 244.100	84	14.8	.2	11.2-19.9	84	59.4	1.6	29-109
Snag	9.7	4.7	.7	0-60	6.088	.989	0- 104.870	-	-	-	-	-	-	-	-
Total	100.0	50.2	2.7	0-180	62.151	3.463	0- 286.440	-	-	-	-	-	-	-	-
DBH (21.0-35.9 in):															
Conifer	66.2	12.1	1.1	0-60	49.647	4.685	0- 286.440	101	26.7	.4	21.0-35.8	101	129.3	2.4	79-182
Hardwood	21.3	4.8	.6	0-50	15.999	2.063	0- 155.160	32	24.7	.6	21.7-35.9	32	79.5	3.3	36-127
Snag	12.5	2.4	.4	0-30	9.335	1.874	0- 162.760	-	-	-	-	-	-	-	-
Total	100.0	19.3	1.2	0-60	74.981	3.463	0- 286.440	-	-	-	-	-	-	-	-
DBH (>36.0 in):															
Conifer	81.4	9.1	.8	0-50	131.865	13.748	0- 963.310	96	50.2	1.1	36.3-79.0	96	169.4	3.2	73-259
Hardwood	5.0	.8	.2	0-20	8.152	2.151	0- 201.610	5	43.4	4.4	36.8-60.8	5	75.6	8.3	48-98
Snag	13.6	1.5	.3	0-20	22.036	4.661	0- 410.230	-	-	-	-	-	-	-	-
Total	100.0	11.4	.9	0-60	162.053	14.132	0-1011.600	-	-	-	-	-	-	-	-
Subtotal (all DBH intervals):															
Conifer	65.5	81.0	5.3	0-270	220.420	14.431	0-1013.190	-	-	-	-	-	-	-	-
Hardwood	22.1	111.3	7.5	0-520	74.391	4.975	0- 340.830	-	-	-	-	-	-	-	-
Snag	12.4	27.6	2.6	0-200	41.832	5.650	0- 410.230	-	-	-	-	-	-	-	-
Total (all DBH intervals):	100.0	219.9	8.2	0-610	336.643	14.054	0-1092.800	-	-	-	-	-	-	-	-

Table 7 (continued).

	$\bar{x}$	$\bar{x}$ + S.E.	Range
Percent ground cover:			
Trees less than 4 in DBH	32.1	1.9	0-99.9
Shrub	8.1	.9	0-77.7
Herb	9.2	1.2	0-98.2
Litter (diameter = < 1 in)	92.7	.9	2.2-99.9
Logs			
diameter = 1 to 12 in	5.2	.5	0-73.3
diameter = > 12 in	1.9	.3	0-27.1
Percent canopy closure:			
Percent total canopy closure	87.0	1.3	0-98
Elevation (ft):	3326.7	45.6	1700-4590

	n	% Frequency of occurrence
Decadence ratings:		
Level 1 (tree dead < 1 year)	70	36.6
Level 2 (tree dead 1-5 years)	47	24.6
Level 3 (tree dead > 5 years)	74	38.7
Total:	191	100.0
Aspect:		
North	94	49.2
East	65	34.0
South	12	6.3
West	20	10.5
Total:	191	100.0

1/ Core areas were an aggregation of timber stand polygons which accounted for greater than 55% of an owl's total number of foraging locations.

2/ For each interval: Conifer = live, conifer trees; Hardwood = live, hardwood trees; Snag = conifer and hardwood, snag trees combined; Total = conifer, hardwood, and snag trees combined.

3/ Mean ($\bar{x}$) represents the mean of means.

4/ Shrub layers are: Layer 1, 0-3.3 ft.; Layer 2, 3.3-6.6 ft.; Layer 3, 6.6-9.9 ft.; Layer 4, 9.9-13.2 ft.; Layer 5, 13.2-16.5 ft.; Layer 6, 16.5-19.8 ft.; Layer 7, 19.8-23.1 ft.

Table 8 (continued).

Shrub layer characteristics:
(percent frequency of occurrence)

Shrub species	Shrub layer[4] 1 n	1 %	2 n	2 %	3 n	3 %	4 n	4 %	5 n	5 %	6 n	6 %	7 n	7 %
Douglas-fir, *Pseudotsuga menziesii*	1	3.3	2	6.7			1	3.3			2	6.7	2	6.7
tanoak, *Lithocarpus densiflorus*	7	23.3	8	26.7	2	6.7	4	13.3	4	13.3	2	6.7	4	13.3
canyon-liveoak, *Quercus chrysolepis*	1	3.3	2	6.7	2	6.7	2	6.7					1	3.3
red alder *Alnus rubra*														
big-leaf maple, *Acer macrophyllum*							2	6.7						
incense cedar, *Taxus brevifolia*			2	6.7	1	3.3								
California hazel, *Corylus cornuta*	1	3.3	1	3.3	2	6.7								
buckbrush, *Ceanothus cuneatus*														
poison oak, *Rhus diversiloba*	5	16.7												
sword fern *Polystichum munitum*	5	16.7												
salal, *Gaultheria shallon*	2	6.7												
Oregon grape, *Berberis nervosa*	1	3.3												
Layer not present	7	23.3	15	50.0	23	76.7	21	70.0	26	86.7	26	86.7	22	73.3
Total:	30	100.0	30	100.0	30	100.0	30	100.0	30	100.0	30	100.0	30	100.0

Table 9. Habitat Characteristics for 4 Female Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 - 24 August 1981. Results are based on .1 ac (.04 ha), circular plots (n = 248). All habitat areas are combined.[1]

Canopy characteristics:

Interval[2]	% Composition (basis = basal area)	stems/acre			Basal area (ft^2/ac)			Diameter at breast height (DBH; in)[3]				Height (ft)[3]			
		$\bar{x}$	± S.E.	Range	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range
DBH (4.0-4.9 in):															
Conifer	21.1	5.9	.8	0-80	.673	.085	0- 9.270	55	4.5	.1	4.0-4.9	55	31.6	.9	17-51
Hardwood	65.2	18.7	1.4	0-120	2.083	.158	0- 13.190	134	4.5	.1	4.0-4.9	134	26.1	.6	7-42
Snag	13.7	4.1	.6	0-60	.439	.061	0- 6.160	-	-	-	-	-	-	-	-
Total	100.0	28.7	1.6	0-140	3.195	.175	0- 15.000	-	-	-	-	-	-	-	-
DBH (5.0-10.9 in):															
Conifer	30.0	28.1	2.3	0-160	9.334	.784	0- 64.240	87	7.6	.1	5.6-10.4	87	53.2	1.5	25-94
Hardwood	60.3	63.1	4.1	0-470	18.754	1.293	0- 153.360	148	7.1	.1	5.1-10.0	148	41.2	.9	6-82
Snag	9.7	10.4	1.1	0-130	3.031	.349	0- 32.610	-	-	-	-	-	-	-	-
Total	100.0	101.6	4.0	0-470	31.119	1.300	0- 153.360	-	-	-	-	-	-	-	-
DBH (11.0-20.9 in):															
Conifer	50.9	19.2	1.8	0-150	24.410	2.416	0- 202.600	112	14.7	.2	11.0-20.8	112	92.7	1.9	38-162
Hardwood	41.5	17.4	1.3	0-110	19.917	1.479	0- 115.540	109	14.5	.2	11.2-20.9	109	68.8	1.6	42-127
Snag	7.6	3.1	.5	0-60	3.621	.568	0- 67.090	-	-	-	-	-	-	-	-
Total	100.0	39.7	2.2	0-200	47.948	2.737	0- 232.830	-	-	-	-	-	-	-	-
DBH (21.0-35.9 in):															
Conifer	68.3	10.1	.8	0-90	41.416	3.513	0- 281.710	111	27.5	.3	21.1-35.9	111	139.9	3.3	43-241
Hardwood	21.7	3.4	.5	0-40	13.130	1.841	0- 178.760	41	26.3	.6	21.0-35.7	41	82.5	3.3	35-126
Snag	10.0	1.6	.3	0-30	6.060	1.089	0- 109.150	-	-	-	-	-	-	-	-
Total	100.0	15.1	.9	0-90	60.606	3.973	0- 281.710	-	-	-	-	-	-	-	-
DBH (>36.0 in):															
Conifer	90.5	14.1	.9	0-60	199.215	12.325	0- 903.110	166	51.3	.8	36.2-90.8	166	179.3	1.9	98-244
Hardwood	2.2	.4	.1	0-20	4.931	1.974	0- 410.380	1	36.1	-	-	1	73.8	-	-
Snag	7.3	1.3	.2	0-20	15.873	3.124	0- 340.380	-	-	-	-	-	-	-	-
Total	100.0	15.8	.9	0-60	220.019	12.924	0-1011.600	-	-	-	-	-	-	-	-
Subtotal (all DBH intervals):															
Conifer	75.8	77.4	4.0	0-390	275.048	12.252	0- 951.570	-	-	-	-	-	-	-	-
Hardwood	16.2	103.0	5.9	0-640	58.815	3.576	0- 462.740	-	-	-	-	-	-	-	-
Snag	8.0	20.5	1.8	0-260	29.024	3.494	0- 341.580	-	-	-	-	-	-	-	-
Total (all DBH intervals):	100.0	200.9	5.9	0-670	362.887	12.445	0-1092.800	-	-	-	-	-	-	-	-

Table 9 (continued).

	$\bar{x}$	$\bar{x}$ + S.E.	Range
Percent ground cover:			
Trees less than 4 in DBH	37.1	1.7	0-99.9
Shrub	6.8	.8	0-82.8
Herb	6.7	.8	0-86.0
Litter (diameter = < 1 in)	90.9	.9	0-99.9
Logs			
diameter = 1 to 12 in	7.3	.7	0-97.0
diameter = > 12 in	2.0	.3	0-50.4
Percent canopy closure:			
Percent total canopy closure	87.6	1.1	0-99.0
Elevation (ft):	3099.9	34.8	2080-4580

	n	% Frequency of occurrence
Decadence ratings:		
Level 1 (tree dead < 1 year)	48	19.4
Level 2 (tree dead 1-5 years)	61	24.6
Level 3 (tree dead > 5 years)	139	56.0
Total:	248	100.0
Aspect:		
North	124	50.0
East	67	27.0
South	37	14.9
West	20	8.1
Total:	248	100.0

1/ Habitat areas are: core area (n = 207) - an aggregation of timber stand polygons which accounted for greater than 55% of an owl's total number of foraging locations; non-core area (n = 18) - area exclusive of core area; roost (n = 23) - verified roost locations.

2/ For each interval: Conifer = live, conifer trees; Hardwood = live, hardwood trees; Snag = conifer and hardwood, snag trees combined; Total = conifer, hardwood, and snag trees combined.

3/ Mean ($\bar{x}$) represents the mean of means.

Table 10 (continued).

Shrub layer characteristics:
(percent frequency of occurrence)

Shrub species	Shrub layer[4] 1 n	1 %	2 n	2 %	3 n	3 %	4 n	4 %	5 n	5 %	6 n	6 %	7 n	7 %
Douglas-fir, *Pseudotsuga menziesii*														
tanoak, *Lithocarpus densiflorus*	6	26.1	10	43.5	5	21.7	6	26.1	3	13.0	4	17.4	1	4.3
canyon-liveoak, *Quercus chrysolepis*	3	13.0	3	13.0			3	13.0					3	13.0
red alder *Alnus rubra*														
big-leaf maple, *Acer macrophyllum*														
incense cedar, *Taxus brevifolia*														
California hazel, *Corylus cornuta*	1	4.3												
buckbrush, *Ceanothus cuneatus*														
poison oak, *Rhus diversiloba*														
sword fern *Polystichum munitum*	1	4.3												
salal, *Gaultheria shallon*														
Oregon grape, *Berberis nervosa*														
Layer not present	12	52.2	10	43.5	18	78.3	14	60.9	20	87.0	19	82.6	19	82.6
Total:	23	100.0	23	100.0	23	100.0	23	100.0	23	100.0	23	100.0	23	100.0

Table 11. Core Area Habitat Characteristics for 4 Female Northern Spotted Owls on the Six Rivers National Forest, Humboldt County, California, 9 July 1980 - 24 August 1981.[1] Results are based on .1 ac (.04 ha), circular plots (n = 207).

Canopy characteristics:

Interval[2]	% Composition (basis = basal area)	stems/acre			Basal area (ft^2/ac)			Diameter at breast height (DBH; in)[3]				Height (ft)[3]			
		$\bar{x}$	± S.E.	Range	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range	n	$\bar{x}$	± S.E.	Range
DBH (4.0-4.9 in):															
Conifer	23.0	6.7	.8	0-80	.755	.099	0- 9.270	47	4.5	.1	4.1-4.9	47	31.8	1.1	17-51
Hardwood	62.5	18.5	1.5	0-110	2.053	.168	0- 11.860	111	4.5	.1	4.0-4.9	111	26.3	.6	7-42
Snag	14.5	4.4	.7	0-60	.476	.072	0- 6.160	-	-	-	-	-	-	-	-
Total	100.0	29.6	1.7	0-140	3.284	.139	0- 15.000	-	-	-	-	-	-	-	-
DBH (5.0-10.9 in):															
Conifer	30.9	28.9	2.5	0-160	9.559	.861	0- 64.240	75	7.5	.1	5.7-10.1	75	53.1	1.7	25-94
Hardwood	60.0	61.8	4.5	0-470	18.543	1.419	0- 153.360	122	7.2	.1	5.1-10.0	122	42.2	1.1	6-82
Snag	9.1	10.1	1.3	0-130	2.852	.366	0- 32.610	-	-	-	-	-	-	-	-
Total	100.0	100.8	4.3	0-470	30.954	1.389	0- 153.360	-	-	-	-	-	-	-	-
DBH (11.0-20.9 in):															
Conifer	51.6	19.8	2.0	0-150	25.405	2.704	0- 202.600	95	14.6	.2	11.0-20.5	95	93.9	2.0	38-162
Hardwood	40.7	17.4	1.4	0-110	20.026	1.628	0- 115.540	90	14.4	.2	11.2-20.9	90	68.9	1.6	42-127
Snag	7.7	3.2	.5	0-60	3.798	.649	0- 67.090	-	-	-	-	-	-	-	-
Total	100.0	40.4	2.4	0-200	49.229	3.064	0- 232.830	-	-	-	-	-	-	-	-
DBH (21.0-35.9 in):															
Conifer	68.7	10.0	.8	0-60	41.308	3.861	0- 236.660	90	27.4	.4	21.1-35.3	90	142.9	3.6	54-241
Hardwood	22.0	3.5	.4	0-30	13.178	1.900	0- 144.650	36	26.3	.7	21.0-35.7	36	81.6	3.6	35-126
Snag	9.3	1.6	.3	0-20	5.607	1.048	0- 91.320	-	-	-	-	-	-	-	-
Total	100.0	15.1	1.0	0-60	60.093	4.262	0- 236.660	-	-	-	-	-	-	-	-
DBH (>36.0 in):															
Conifer	90.9	14.3	1.0	0-60	205.229	13.654	0- 903.110	140	51.8	.8	36.2-77.9	140	179.5	2.1	115-242
Hardwood	2.4	.5	.1	0-20	5.567	2.339	0- 410.380	1	36.1	-	-	1	73.8	-	-
Snag	6.7	1.2	.2	0-20	15.043	3.416	0- 340.380	-	-	-	-	-	-	-	-
Total	100.0	16.0	1.0	0-60	225.839	14.306	0-1011.600	-	-	-	-	-	-	-	-
Subtotal (all DBH intervals):															
Conifer	76.4	79.7	4.5	0-390	282.256	13.571	0- 951.570	-	-	-	-	-	-	-	-
Hardwood	16.1	101.7	6.3	0-640	59.367	3.987	0- 462.740	-	-	-	-	-	-	-	-
Snag	7.5	20.5	2.1	0-260	27.776	3.681	0- 341.580	-	-	-	-	-	-	-	-
Total (all DBH intervals):	100.0	201.9	6.4	0-670	369.399	13.712	0-1092.800	-	-	-	-	-	-	-	-

Table 11 (continued).

	$\bar{x}$	$\bar{x}$ + S.E.	Range
Percent ground cover:			
Trees less than 4" DBH	37.5	1.9	0-99.9
Shrub	6.6	.8	0-82.8
Herb	6.0	.8	0-86.0
Litter (diameter = < 1 in)	90.8	.9	0-99.9
Logs			
diameter = 1 to 12 in	7.1	.6	0-82.2
diameter = > 12 in	1.9.	.3	0-50.4
Percent canopy closure:			
Percent total canopy closure	88.5	1.0	0-99.0
Elevation (ft):	3158.9	38.1	2280-4580

	n	% Frequency of occurrence
Decadence ratings:		
Level 1 (tree dead < 1 year)	35	16.9
Level 2 (tree dead 1-5 years)	53	25.6
Level 3 (tree dead > 5 years)	119	57.5
Total:	207	100.0
Aspect:		
North	108	52.2
East	57	27.5
South	25	12.1
West	17	8.2
Total:	207	100.0

1/ Core areas were an aggregation of timber stand polygons which accounted for greater than 55% of an owl's total number of foraging locations.

2/ For each interval: Conifer = live, conifer trees; Hardwood = live, hardwood trees; Snag = conifer and hardwood, snag trees combined; Total = conifer, hardwood, and snag trees combined.

3/ Mean ($\bar{x}$) represents the mean of means.

4/ Shrub layers are: Layer 1, 0-3.3 ft.; Layer 2, 3.3-6.6 ft.; Layer 3, 6.6-9.9 ft.; Layer 4, 9.9-13.2 ft.; Layer 5, 13.2-16.5 ft.; Layer 6, 16.5-19.9 ft.; Layer 7, 19.8-23.1 ft.

Table 12 (continued).

Shrub layer characteristics:
(percent frequency of occurrence)

Shrub species	Shrub layer[4] 1 n	1 %	2 n	2 %	3 n	3 %	4 n	4 %	5 n	5 %	6 n	6 %	7 n	7 %
Douglas-fir, *Pseudotsuga menziesii*					1	5.6	2	11.1			4.	22.2	2	11.1
tanoak, *Lithocarpus densiflorus*	1	5.6	3	16.7	3	16.7	4	22.2			1	5.6		
canyon-liveoak, *Quercus chrysolepsis*	1	5.6												
red alder *Alnus rubra*														
big-leaf maple, *Acer macrophyllum*														
incense cedar, *Taxus brevifolia*														
California hazel, *Corylus cornuta*					1	5.6								
buckbrush, *Ceanothus cuneatus*														
poison oak, *Rhus diversiloba*	1	5.6												
sword fern *Polystichum munitum*														
salal, *Gaultheria shallon*														
Oregon grape, *Berberis nervosa*														
Layer not present	15	83.3	15	83.3	13	72.2	12	66.7	18	100	13	72.2	16	88.9
Total:	18	100.0	18	100.0	18	100.0	18	100.0	18	100.0	18	100.0	18	100.0

Table 2. Mean Diameter at Breast Height (DBH), Height (HT), and Basal Area (BA) for Snag Species.

Snag species	n	Occur.	DBH (in) x	+ S.E.	range	HT (ft) x	+ S.E.	range	BA (ft^2/ac) x	+ S.E.	range
Douglas-fir, *Pseudotsuga menziesii*	502	50.7	13.0	.6	4.0-79.0	38.5	1.6	6-208	.411	.043	.087-34.038
tanoak, *Lithocarpus densiflorus*	72	7.3	8.7	.6	4.0-29.0	26.5	1.8	6-78	.575	.103	.087-6.417
Pacific madrone, *Arbutus menziesii*	101	10.2	10.1	.7	4.0-59.0	28.9	3.5	6-102	.832	.200	.087-18.985
canyon-live oak, *Quercus chrysolepis*	9	1.0	8.2	1.1	4.2-14.0	18.2	2.3	7-30	.429	.114	.096-1.115
big-leaf maple, *Acer macroplyllum*	7	0.7	7.8	1.1	5.1-13.0	18.3	6.7	7-57	.375	.108	.142-.936
incense cedar, *Libocedrus decurrens*	17	1.7	9.4	2.9	4.0-54.0	23.0	2.6	6-38	1.220	.921	.087-15.904
Oregon white oak, *Quercus garryana*	70	7.0	6.0	.4	4.0-28.0	22.1	1.4	7-88	.268	.071	.087-4.185
California black oak, *Quercus kelloggii*	126	12.7	12.5	.7	4.4-44.0	28.6	1.6	6-114	1.166	.145	.106-10.704
Pacific yew, *Taxus brevifolia*	4	0.4	7.8	1.2	5.8-11.4	16.3	4.5	8-29	.355	.120	.184-.709
Sugar pine, *Pinus lambertiana*	18	1.8	24.1	5.0	4.4-67.4	67.4	14.3	7-186	5.561	1.981	.106-24.776
Jeffrey pine, *Pinus jeffreyi*	2	0.2	32.8	6.4	26.4-39.2	84.5	3.5	81-88	6.091	2.290	3.801-8.381
ponderosa pine, *Pinus ponderosa*	2	0.2	25.7	20.1	5.5-45.8	93.5	76.5	17-170	1.305	5.638	.165-11.441
white fir, *Abies concolor*	53	5.3	15.9	1.5	4.6-48.4	39.3	4.7	6-163	1.967	.407	.115-12.776
chinquapin, *Castanopsis chrysophylla*	8	0.8	10.5	2.1	4.4-22.0	19.1	4.4	6-39	.781	.305	.106-2.639
TOTAL:	991	100.0									

Table 1. Subsets of variables entered into discriminant analyses.

Variable	Discriminant Analysis [1]								
	Habitats		Sexes			Males		Females	
	Sexes Combined	Males vs. Females	Roost	Core	Non-core	All habitats	Core vs. non-core	All habitats	Core vs. non-core
Tree density and basal area by species:									
Douglas-fir, *Pseudotsuga menziesii*									
density									
live tree		x		x	x		x		
snag tree					x		x		
basal area									
live tree								x	
snag tree									x
white fir, *Abies concolor*									
density									
live tree		x	x	x					
basal area									
live tree	x					x	x		
snag tree				x					
Pacific yew, *Taxus brevifolia*									
density									
live tree			x		x	x	x		
snag tree								x	
basal area									
live tree						x			
snag tree					x			x	
Ponderosa pine, *Pinus ponderosa*									
density									
live tree				x		x	x		
snag tree				x					
basal area									
live tree						x	x		
Tree density and basal area by species:									
Jeffrey pine, *Pinus jeffreyi*									
basal area									
live tree				x					
snag tree				x					
Incense cedar, *Libocedrus decurrens*									
density									
live tree				x					
snag tree				x					
basal area									
live tree				x	x	x		x	x
snag tree									

Table 1 (continued).

Variable	Discriminant Analysis [1]								
	Habitats		Sexes			Males		Females	
	Sexes Combined	Males vs. Females	Roost	Core	Non-core	All habitats	Core vs. non-core	All habitats	Core vs. non-core
Pacific madrone, Arbutus menziesii									
density									
live tree	X	X	X	X			X	X	X
snag tree		X	X	X	X	X	X	X	X
basal area									
alive tree									
snag tree				X	X	X	X		X
Tree density and basal area by species:									
mountain dogwood, Cornus nuttallii									
density									
live tree				X		X			
basal area									
live tree			X	X					
canyon-live oak, Quercus chrysolepis									
density									
live tree			X	X	X	X	X		
snag tree								X	
basal area									
live tree	X	X		X	X			X	X
snag tree			X	X		X		X	
chinquapin, Castanopsis chrysophylla									
density									
live tree				X		X			
snag tree				X		X			
basal area									
live tree				X					X
snag tree				X		X			
Tree density and basal area by DBH interval:									
10.0-12.3 cm DBH									
density									
live conifer tree	X	X		X		X	X		
live hardwood tree						X			
snag tree			X	X					
total tree				X					
basal area									
live conifer tree		X						X	
live hardwood tree							X		

Table 1 (continued).

Variable	Discriminant Analysis [1]								
	Habitats		Sexes			Males		Females	
	Sexes Combined	Males vs. Females	Roost	Core	Non-core	All habitats	Core vs. non-core	All habitats	Core vs. non-core
snag tree					X				
Total tree density and basal area (all DBH intervals combined):									
density									
snag tree		X	X	X					X
total tree	X	X		X		X	X		
basal area									
live conifer tree					X				
live hardwood tree					X				
snag tree		X	X	X					X
total tree	X		X						
Canoy closure:	X	X	X	X	X	X	X	X	X
decadence:									
trees dead 1-5 years	X	X	X	X	X	X	X	X	X
trees dead >5 years	X	X	X	X	X	X	X	X	X
Ground cover:									
trees < 10.0 cm DBH	X	X	X	X	X	X	X	X	X
shrub	X	X						X	
herb	X	X	X	X	X	X	X	X	
litter		X		X					X
logs									
diameter = 2.5-30.0 cm	X	X	X	X	X	X	X	X	X
diameter = > 30.0 cm	X	X	X		X	X	X	X	X
Physiography:									
aspect									
north	X	X	X	X	X	X	X	X	X
east	X	X	X	X	X	X	X	X	X
south	X	X	X	X	X	X	X	X	X
elevation	X	X	X	X	X	X	X	X	X
TOTAL	27	32	30	61	36	44	45	38	35

1/ X = Variable entered into analysis.

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